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# THE SCIENTIFIC MONTHLY

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# THE SCIENTIFIC MONTHLY

FEBRUARY, 1920


## THE TERMITODOXA, OR BIOLOGY AND SOCIETY[1]


By Professor WILLIAM MORTON WHEELER

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JUST before the World War we seemed to be on the verge of startling revelations in animal behavior. "Rolf," the Ayrdale terrier of Mannheim, was writing affectionate letters to Professor William Mackenzie of Genoa, and the Elberfeld stallions were easily solving such problems in mental arithmetic as extracting the cube root of 12,167, to the discomfiture of certain German professors, who had never been able to detect similar signs of intelligence in their students. The possibilities of animal correspondence struck me as so promising that I longed to dispatch letters and questionnaires to all the unusual insects of my acquaintance. But dismayed at the thought of the quantity of mail that might reach me, especially from the many insects that have been misrepresented by the taxonomists or maltreated by the economic entomologists, I decided to proceed with caution and to confine myself at first to a single letter to the most wonderful of all insects, the queen of the West African *Termes bellicosus*. During the autumn of 1915 my friend, Mr. George Schwab, missionary to the Kamerun, kindly undertook to deliver my communication to a populous termitarium of this species in his back yard in the village of Okani Olinga. He subsequently wrote me that my constant occupation with the ants must have blinded me to the fact that the termitarium, unlike the formicarium, contains a king as well as a queen, but that the *bellicosus* king was so accustomed to being overlooked, even by his own offspring, that he not only pardoned my discourtesy but condescended to

[1] Read at the Symposium of The American Society of Naturalists, Princeton Meeting, Dec. 30th, 1919.

answer my letter. Mr. Schwab embarked for Boston in 1917. Off the coast of Sierra Leone his steamer was shelled by a German submarine camouflaged as a small boat in distress, but succeeded in escaping and what would have been another atrocity, the loss of the king's letter, was averted. It runs as follows:

*Dear Sir:* Your communication addressed to my most gloriously physogastric consort, was duly received. Her majesty, being extremely busy with oviposition—she has laid an egg every three minutes for the past four years—and fearing that an interruption of even twenty minutes might seriously upset the exquisitely balanced routine of the termitarium, has requested me to acknowledge your expression of anxiety concerning the condition of the society in which you are living and to answer your query as to how we termites, to quote your own words, "managed to organize a society which, if we accept Professor Barrell's recent estimates of geological time, based on the decomposition of radium, has not only existed but flourished for a period of at least a hundred million years."

I answer your question the more gladly, because the history of our society has long been with me a favorite topic of study. As you know, the conditions under which I live are most conducive to sustained research. I am carefully fed, have all the leisure in the world and the royal chamber is not only kept absolutely dark and at a constant and agreeable temperature even during the hottest days of the Ethiopian summer, but free from all noises except the gentle rhythmic dropping of her majesty's eggs and the soft footfalls of the workers on the cement floor as they carry away the germs of future populations to the royal nurseries. And you will not wonder at my knowledge of some of the peculiarities of your society when I tell you that in my youth I belonged to a colony that devoured and digested a well-selected library belonging to a learned missionary after he had himself succumbed to the appetite of one of the fiercest tribes of the Kamerun. If I extol the splendid solutions of sociological problems by my remote ancestors, I refrain from suggesting that your society would do well to imitate them too closely. This, indeed, would be impossible. I believe, nevertheless, that you may be interested in my remarks, for, though larger and more versatile, you and your fellow human beings are after all only animals like myself.

According to tradition our ancestors were descended in early Cretaceous times from certain kind-hearted old cockroaches that lived in logs and fed on rotten wood and mud.

Their progeny, the aboriginal termites, although at first confined to this apparently unpromising diet, made two important discoveries. First, they chanced to pick up a miscellaneous assortment of Protozoa and Bacteria and adopted them as an intestinal fauna and flora, because they were able to render the rotten wood and mud more easily digestible. The second discovery, more important but quite as incidental, was nothing less than society. Our ancestors, like other solitary insects, originally set their offspring adrift to shift for themselves as soon as they hatched, but it was found that the fatty dermal secretions, or exudates of the young, were a delicious food and that the parents could reciprocate with similar exudates as well as with regurgitated, predigested cellulose. Thenceforth parents and offspring no longer lived apart, for an elaborate exchange of exudates, veritable social hormones, was developed, which, continually circulating through the community, bound all its individuals together in one blissful, indissoluble, syntrophic whole, satisfied to make the comminution and digestion of wood and mud the serious occupation of existence, but the swapping of exudates the delight of every leisure moment. It may be said, therefore, that our society did not arise, like yours, from a combination of selfish predatism and parasitism but from a coöperative mutualism, or symbiosis. In other words, our ancestors did not start society because they thought they loved one another, but they loved one another because they were so sweet, and society supervened as a necessary and unforeseen by-product.

You will admit that no society could have embarked on its career through the ages with more brilliant prospects. The world was full of rotten wood and mud and no laws interfered with distilling and imbibing the social hormones. But in the Midcretaceous our ancestors struck a snag. Not only had all the members of society begun to reproduce in the wildest and most unregulated manner, but their behavior toward one another had undergone a deterioration most shocking to behold. The priests, pedagogues, politicians and journalists having bored their way up to the highest strata of the society undertook to influence or control all the activities of its members. The priests tried to convince the people that if they would only give up indulging in the social hormones and confine themselves to a diet of pure mud, they would in a future life eat nothing but rose-wood and mahogany, and the pedagogues insisted that every young termite must thoroughly saturate himself with the culture and languages of the Upper Carboniferous cockroaches.

Some suspected that the main value of this form of education lay in intensifying and modulating the stridulatory powers, but for several thousand years most termites implicitly believed that ability to stridulate, both copiously and sonorously, was an infallible indication of brain-power. The politicians and the journalists—well, were it not that profanity has been considered to be very bad form in termite society since the Miocene, I might make a few comments on *their* activities. Suffice it to say that they consumed even more cellulose than the priests and pedagogues and secreted such a quantity of buncombe and flapdoodle that they well nigh asphyxiated the whole termitarium. Meanwhile in the very foundations of the commonwealth anarchists, syndicalists, I. W. W. and bolsheviki were busy boring holes and filling them with dynamite, while the remainder of society was largely composed of profiteers, grafters, shysters, drug-fiends and criminals of all sizes interspersed with beautifully graduated series of wowsers, morons, feeble-minded, idiots and insane. [At this point the king has introduced a rather trivial note on the word "wowser." This word, he says, was first employed by the termites of Australia but later adopted by the human inhabitants of that continent, to designate an individual who makes a business of taking the joy out of life, one who delights in pouring cold water into his own and especially into other peoples' soup. The term appears to be onomatopœic to judge from a remark by one of our postcretaceous philologists who asserts that "whenever the wowser saw termites dancing, swearing, flirting, smoking or over-indulging in the social hormones, he sat up on his hind legs, looked very solemn, swelled out his abdomen and said Wow!"]

To such depths, my dear sir, the letter continues, had termite society fallen in the Midcretaceous. The few sane termites still extant were on the point of giving up social life altogether and of returning to the solitary habits of the Palæodictyoptera, but a king, Wuf-wuf IV., of the 529th dynasty, succeeded in initiating those reforms which led our ancestors to complete the most highly integrated social organization on the planet. He has aroused the enthusiastic admiration and emulation of every sovereign down to the present time. I can best describe him by saying that in his serious moments he displayed the statesmanship of a Hammurabi, Moses, Solomon, Solon and Pericles rolled into one and that in his moments of relaxation he was a delightful blend of Aristophanes, Lucian, Rabelais, Anatole France and Bernard Shaw. This king had the happy

thought to refer the problems of social reform to the biologists. They were unfortunately few in number and difficult to find, because each was sitting in his hole in some remote corner of the termitarium, boring away in blissful ignorance of the depravity of the society to which he belonged. In obedience to the king's request, however, they were finally rounded up and persuaded to meet together annually just after the winter solstice for the purpose of stridulating about the relations of biology to society. After doing this for ten million years they adopted a program as elegant as it was drastic for the regeneration of termite society, and during the remaining fifteen million years of the Cretaceous they succeeded in putting their plan into operation. I can give you only the baldest outline of this extraordinary achievement.

Our ancient biological reformers started with the assumption that a termite society could not be a success unless it was constructed on the plan of a superorganism, and that such a superorganism must necessarily conform to the fundamental laws of the individual organism. As in the case of the individual, its success would have to depend on the adequate solution of the three basic problems of nutrition, reproduction and protection. It was evident, moreover, that these problems could not be solved without a physiological division of labor among the individuals composing the society, and this, of course, implied the development of classes, or castes. Termite society was therefore divided into three distinct castes, according to the three fundamental organismal needs and functions, the workers being primarily nutritive, the soldiers defensive and the royal couple reproductive. Very fortunately our earliest social ancestors had not imitated our deadly enemies, the ants, who went crazy in the early Cretaceous on the subject of parthenogenesis and developed a militant suffragette type of society, but insisted on an equal representation of both sexes in all the social activities. Our society is therefore ambisexual throughout, so that, unlike the ants, we have male as well as female soldiers and workers. It was early decided that these two castes should be forbidden to grow wings or reproduce and that the royal caste should be relieved from all the labor of securing food and defending the termitarium in order to devote all its energies to reproduction. The carrying out of this scheme yielded at least two great advantages: first, the size of the population could be automatically regulated to correspond with the food-supply, and second, the production of perfect offspring was greatly facilitated.

During the late Cretaceous period of which I am writing our practical geneticists, in obedience to a general demand for a more varied diet, made two important contributions to our social life. The plant breeders found that what was left of the comminuted wood after its passage through the intestines of the worker termites could be built up in the form of elaborate sponge-like structures and utilized as gardens for the growth of mushrooms. Cultivation was later restricted to a few selected varieties of mushrooms which the biochemists had found to contain vitamins that accelerated the growth of the tissues in general and of the spermatocytes and oöcytes in particular. And for this reason only the royal caste and the young of the other castes were permitted to feed on this delicious vegetable food. The animal breeders of that age made a more spectacular though less useful contribution when they persuaded our ancestors to adopt a number of singular beetles and flies and to feed and care for them till they developed exudate organs. Owing to the stimulating quality of their exudates these creatures, the termitophiles, added much variety to the previously somewhat monotonous social hormones. This quality, however, made it necessary to restrict the number of termitophiles in the termitarium for the same reason that your society would find it advisable to restrict the cattle industry if your animal breeders had succeeded in producing breeds of cows that yielded highballs and cocktails instead of milk.

It is, of course, one thing to have a policy and quite another to carry it out. The anarchistic elements in our late Cretaceous society were so numerous and so active that great difficulty was at first experienced in putting the theories of the biological reformers into practise, but eventually, just before the Eocene Tertiary, a very effective method of dealing with any termite that attempted to depart from the standards of the most perfect social behavior was discovered and rigorously applied. The culprit was haled before the committee of biochemists who carefully weighed and examined him and stamped on his abdomen the number of his colloidal molecules. This number was taken to signify that his conduct had reduced his social usefulness to the amount of fat and proteids in his constitution. He was then led forth into the general assembly, dismembered and devoured by his fellows.

I describe these mores reluctantly and very briefly, because I fear that they may shock your sensibilities, but some mention of them is essential to an appreciation of certain developments in our society within recent millennia. So perfectly socialized

have we now become that not infrequently a termite who has a slight indisposition, such as a sore throat or a headache or has developed some antisocial habit of thought or is merely growing old, will voluntarily resort to the committee of biochemists and beg them to stamp him. He then walks forth with a radiant countenance, stridulating a refrain which is strangely like George Eliot's "O, may I join the choir invisible!" and forthwith becomes the fat and proteid "Bausteine" of the crowd that assembles on hearing the first notes of his petition. If you regard this as an even more horrible exhibition of our mores, because it adds suicide to murder and cannibalism, I can only insist that you are viewing the matter from a purely human standpoint. To the perfectly socialized termite nothing can be more blissful or exalted than feeling the precious fats and proteids which he has amassed with so much labor, melting, without the slightest loss of their vital values, into the constitutions of his more vigorous and socially more efficient fellow beings.

Now I beg you to note how satisfactory was our solution of the many problems with which all animals that become social are confronted. I need hardly emphasize the matter of nutrition, for you would hardly contend that animals that can digest rotten wood and mud, grow perennial crops of mushrooms on their excrement, domesticate strange animals to serve as animated distilleries and digest not only one anothers' bodies but even one anothers' secretions, have anything to learn in dietetics or food conservation. Our solution of the great problems of reproduction, notably those of eugenics, is if anything, even more admirable, for by confining reproduction to a special caste, by feeding it and the young of the other castes on a peculiarly vitaminous diet and by promptly and deftly eliminating all abnormalities, we have been able to secure a physically and mentally perfect race. You will appreciate the force of this statement when I tell you that in a recent census of the 236,498 individuals comprising the entire population of my termitarium, I found none that had hatched with more than the normal number of antennal joints or even with a misplaced macrochæta. The only anomaly seen was one of no social significance, a slightly defective toenail in three workers. Rigid eugenics combined with rigid enforcement of the regulations requiring all antisocial, diseased and superannuated individuals promptly to join the choir invisible, at the same time solved the problems of ethics and hygiene, for we were thus enabled, so to speak, to ram virtue and health back into the germ-plasm

where they belong. And since we thus compelled not only our workers and soldiers but even our kings and queens to be born virtuous and to continue so throughout life, the Midcretaceous wowser caste, finding nothing to do, automatically disappeared. The problem of social protection was solved by the creation of a small standing army of cool-headed, courageous soldiers, to be employed not in waging war but solely for defensive purposes, and the development on the part of the soldiers and workers of ability to construct powerful fortifications. It may be said that the formation of the soldier caste as well as the invention of our cement subway architecture—an architecture unsurpassed in magnitude, strength and beauty, considering the small stature of our laborers and the simple tools they employ—was due to the repeated failures, extending over many million years, of our politicians to form a league of nations with our deadly enemies, the ants. After a recent review of the army and an inspection of the fortifications of my termitarium I agree with several of the kings of the present dynasty who believed that we ought really to be very grateful to our archenemies for their undying animosity.

Such was our society at the beginning of the Eocene, and such with slight improvements in detail, it has remained for the past fifty million years, living and working with perfect smoothness, as if on carefully lubricated ball-bearings. Nor does it, like human society, live and work for itself alone, but with a view to the increase and maintenance of other types of life on the planet. On our activities depend the rapid decomposition of the dead vegetation and the rapid formation of the vegetable mould of the tropics. We are so numerous and our operations of such scope that we are a very important factor in accelerating the growth of all the vegetation, not only of the dry savannahs and pampas but even of huge rain-forests like those of the Congo, the Amazon and the East Indies. And when you stop to consider that the animal and human life of the tropics absolutely depends on this vegetation you will not take too seriously the reports of our detractors who are forever calling attention to our destructive activities. One author, I am told, asserts that certain South American nations can never acquire any culture because the termites so quickly eat up all their libraries, and another gives an account of a gentleman in India who went to bed full of whiskey and soda and awoke in the morning stark naked, because the termites had eaten up his pyjamas. How very unfair to dwell on the loss of a few books and a suit of pyjamas and not even to mention

our beneficent and untiring participation in one of the most important biocœnoses!

You will pardon me if after this hasty sketch of our history I am emboldened to make a few remarks about your society, and in what I say you will, I hope, make due allowance both for the meagerness of my sources of information and the limitations of my understanding. I must confess that to me your society wears a strangely immature and at the same time senile aspect, the appearance, in fact, of a chimera, composed of the parts of an infant and those of a white-haired octogenarian. Although your species has been in existence little more than one hundredth of the time covered by our evolution, you are nevertheless such huge and gifted animals, that it is surprising to find you in so imperfect a stage of socialization. And although every individual in your society seems to crave social integration with his fellows, it seems to be extremely difficult to persuade him to abate one tittle of all his natural desires and appetites, and every individual resists to the utmost any profound specialization of his structure and functions such as would seem to be demanded by the principle of the division of labor in any perfect society. Hence all the attempts which your society is continually making to form classes or castes are purely superficial and such as depend on the accumulation and transmission of property, and on vocation. And owing to the absence of eugenics and birth-control and to your habit of fostering all weak and inefficient individuals, there is not even the dubious and slow-working apparatus of natural selection to provide for the organic fixation of castes through heredity. So immature is your society in these respects that it might be described as a lot of cave-men and cave-women playing at having a perpetual pink tea or Kaffeeklatsch.

But the senile aspect of your society impresses me as even more extraordinary, because our society—and the same is true of that of all other social insects—is perennially youthful and vigorous, owing to our speedy elimination of the old and infirm. And this brings me to a matter that interests me greatly and one on which I hope we shall have much further correspondence. To be explicit, it seems that though your society has no true caste system, it is, nevertheless, divided into what might be called three spurious castes, the young, the mature and the aged. These, of course, resemble our castes only in number and in consisting of individuals of both sexes. They are peculiar in being rather poorly defined, temporary portions of the life-cycle, so that a single individual may belong to all of them

in succession, and in the fact that only one of them, comprising the mature individuals, is of any great economic value to society and therefore actually functions as the host of the two others, which are, biologically speaking, parasitic. To avoid shocking your human sensibilities, I am willing to admit that both these castes may be worth all the care that is bestowed on them, the young on account of their promise and the old on account of past services. And I will even admit the considerable social value of the young and the old as stimuli adapted to call forth the affection of the mature individuals. But, writing as one animal to another, I confess that I am unable to understand why you place the control of your society so completely in the hands of your aged caste. Your society is actually dominated by the superannuated, by old priests, old pedagogues, old politicians and no end of old wowsers of both sexes who are forever suppressing or regulating everything from the observance of the Sabbath and the wearing of feathers on hats to the licking of postage stamps and the grievances and tribulations of stray tom-cats.

I notice that your educators, psychologists and statisticians have much to say on human longevity, and you seem all to crave for nothing so much as an inordinate protraction of your egos. Psychologically, this is, of course, merely another manifestation of your fundamentally unsocial and individualistic appetites. Your writers make much of your long infancy, childhood and adolescence as being very conducive to educability and socialization, and this is doubtless true, but the fact seems to be overlooked that the great lengthening of the initial phases of your life-cycle is also attended by a grave danger, for it also increases the dependence of the young on the adult and aged elements of society, especially on the parents, and this means intensifying what the Freudian psychologists call the father and mother complexes and therefore also an increased subservience to authority, a cult of the conservative, the stable and the senile. The deplorable effects of intensifying these complexes have long been only too evident in your various religious systems and are already beginning to show in the all too ready acceptance on the part of your society of the visionless policies and confused and hesitating methods of administration of your statesmen.

Unless I am much mistaken this matter of the domination of the old in your society deserves careful investigation. Unfortunately very little seems to be known about senility. In our society it can not be investigated, because we do not

permit it to exist, and in your society it is said to be very poorly understood, because no one is interested in it till he actually reaches it and then he no longer has the ability or the time to investigate it. When the social significance of this stage in the human life-cycle comes to be more thoroughly appreciated some of your young biologists and psychologists will make it a subject of exhaustive investigation and will discover the secret of its ominous and persistent domination. It will probably be found that many of your aged are of no economic importance whatever, and that the activities of many others may even be mildly helpful or beneficial, but you will find, as we found in the Midcretaceous, a small percentage, powerful and pernicious out of all proportion to their numbers, who are directly responsible for the deplorable inertia of your institutions, especially of your churches, universities and political bodies. These old individuals combine with a surprising physical vigor, a certain sadistic obstinacy which consecrates itself to obstructing, circumventing, suppressing or destroying not only everything young or new, but everything any other old individual in their environment may suggest. The eminent physician who recommended chloroform probably had this type of old man in mind. Certain economic entomologists have advocated some more vigorous insecticide, such as hydrocyanic acid gas. This is, however, a matter concerning which it might be better to defer recommendation till the physiology, psychology and ethology of the superannuated have been more thoroughly investigated.

It has sometimes occurred to me that your social problem may be quite insoluble—that when your troglodyte ancestors first expanded the family and clan into society they were already too long-lived, too "tough" and too specialized mentally and physically ever to develop the fine adjustments demanded by an ideal social organization. I feel certain, nevertheless, that you could form a much better society than the present if you could be convinced that your further progress depends on solving the fundamental, preliminary problems of nutrition, reproduction and social defence, which our ancestors so successfully solved in the late Cretaceous. These problems are, of course, extremely complicated in your society. Under nutrition you would have to include raw materials and fuel, *i. e.*, food for your factories and furnaces as well as food for your bodies. Your problems of reproduction comprise not only those of your own species but of all your domesticated animals and plants, and your social defence problems embrace not only protection from the enemies of your own species (military science) but

from the innumerable other organic species which attack your domesticated animals and plants as well as your own bodies (hygiene, parasitology, animal and plant pathology, economic entomology). Like our ancestors you will certainly find that these problems can be solved only by the biologists—taking the word "biologists" in its very broadest sense, to include also the psychologists and anthropologists—and that till they have put their best efforts into the solution your theologians, philosophers, jurists and politicians will continue to add to the existing confusion of your social organization. It is my opinion, therefore, that if you will only increase your biological investigators a hundred fold, put them in positions of trust and responsibility much more often and before they are too old, and pay them at least as well as you are paying your plumbers and bricklayers, you may look forward to making as much social progress in the next three centuries as you have made since the Pleistocene. That some such opinion may also be entertained by some of your statesmen sometime before the end of the present geological age, is the sincere wish of

Yours truly,

WEE-WEE, 43d Neotenic King, of the 8429th Dynasty of the Bellicose Termites.

On reperusing this letter before deciding, after many misgivings, to read it to so serious a body of naturalists, I notice a great number of inaccuracies and exaggerations, attributable, no doubt, to his majesty's misinterpretation of his own and very superficial acquaintance with our society. His remarks on old age strike me as particularly inept and offensive. He seems not to be aware of the fact that at least a few of our old men have almost attained to the idealism of the superannuated termite, a fact attested by such Freudian confessions as the following, taken from a letter recently received by one of my colleagues from a gentleman in New Hampshire:

> I do not understand how it is that an insect so small as to be invisible is able to worry my dog and also at times sharply to bite myself. A vet. friend of mine in Boston advised lard and kerosene for the dog. This seemed to check them for a time, but what I need is extermination, for I am in my eighty-fourth year.

# DEFECTS FOUND IN DRAFTED MEN, II

By C. B. DAVENPORT

FORMERLY MAJOR, S. C.

AND

ALBERT G. LOVE

LT. COL., M. C., U. S. A.

14. *Refractive Errors of the Eyes.*—This group of defects is numerically important, having been found in over 30 per 1,000 of the population, a total of about 90,000 men. For the distribution, see Fig. 14. This defect is of great military importance and led to rejection in more than three fourths of the cases. It is of less importance in civil life, since most of the errors are sufficiently correctible to permit a man to carry on ordinary civil occupations. Of the various defects, myopia, short-sightedness, is the commonest. The distribution of myopia is shown in Fig. 15. From this figure it appears that one of the centers of heaviest incidence of errors of refraction is New England and the Middle States. This may be in part due

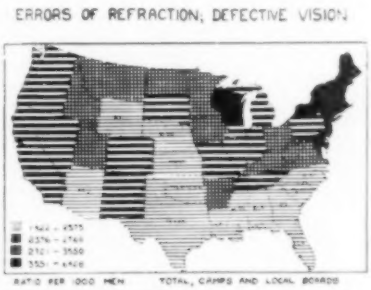



FIG. 14.

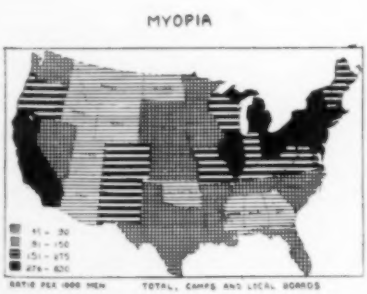



FIG. 15.

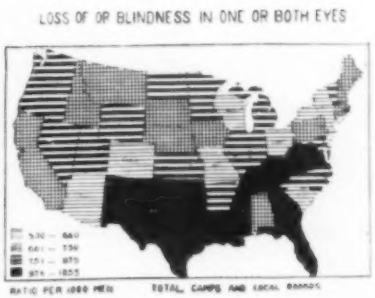



FIG. 16.

to the great care taken by the medical examiners of New England in regard to eye defects. It is, however, certainly very largely due to the presence in New York City and vicinity and in Boston of peoples with a constitutional tendency to myopia. A similar tendency, but less marked, is found in Chicago and in the cities of Ohio and Michigan. Refractional errors are above all a defect of great cities, due primarily to the racial constitution of the population of those cities and secondarily to the overstrain of the eye which comes from clerical and other close work engaged in by a large proportion of the population of these cities. A markedly high incidence of refractive errors is found in those sections containing a large proportion of French-Canadians. The ratio is high also in sections largely occupied by Germans and Austrians.

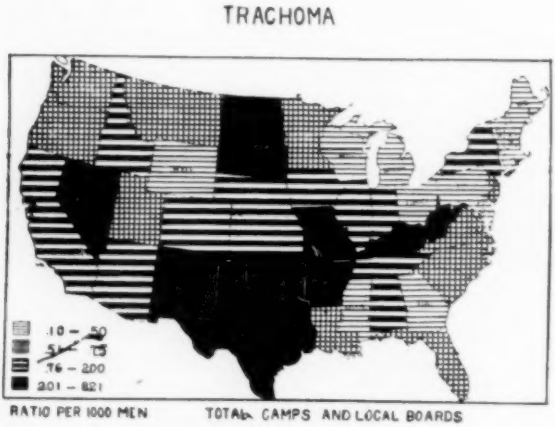



FIG. 17.

15. *Other Eye Diseases and Defects, including Blindness in One or Both Eyes.*—While naturally only a few persons blind in both eyes registered for military service, the number of those blind in one eye was extraordinarily large. There were about 20,000 of them altogether. The distribution is given in Fig. 16, which shows that the center of incidence is in the southern states. This result has probably a combination of causes, such as gonorrhea (which finds its greatest incidence here, and which may blind one eye without affecting the other) and trachoma (Fig. 17), which finds its greatest incidence in the southern states. The extraordinarily large amount of eye defects, other than errors of refraction, in the arid states of the west may well be due in part to the inflammations caused by blazing sun and by dust storms.

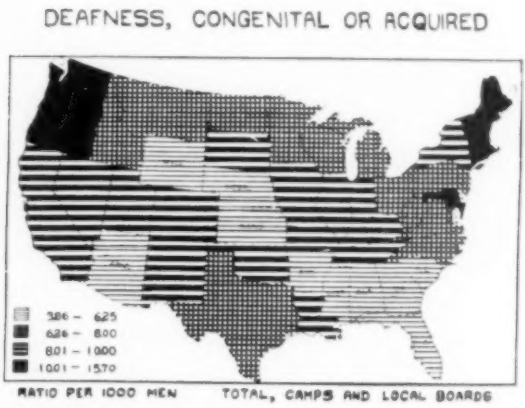



FIG. 18.

16. *Ear Diseases and Defects.*—Defects of hearing, like all defects of the senses, have a great military importance. In the World War, keen hearing was often a matter of life and death, since, if hearing were adequate, gas shells could be distinguished from others in time to put on gas masks. Defects of hearing have, however, less importance in civil life. The number of persons with ear defects and ear diseases found in the population was great. There were about 22,000 with otitis media, or inflammation of the middle ear, and about 20,000 with defective hearing. The inflammation of the middle ear is a serious matter, since it not only frequently leaves a deafness, but often becomes a center of infection that may cause death. It was a prominent cause of rejection, about 75 per cent. of those with otitis media having been rejected for all military service. The distribution of otitis media is shown in Fig. 18. There are two principal centers, one in the New England and Middle States,

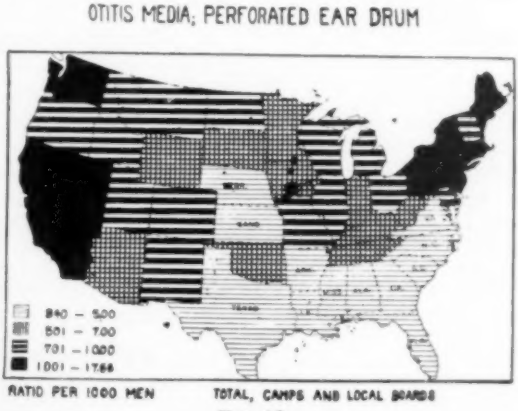



FIG. 19.

and one on the Pacific coast. The point of greatest incidence is New York City, but other centers of recent immigrants in Rhode Island, New Jersey, and Massachusetts have a great amount of infection of the middle ear. There is a relatively small amount of otitis media in the southern states, a fact that is associated with the comparative immunity from this disease

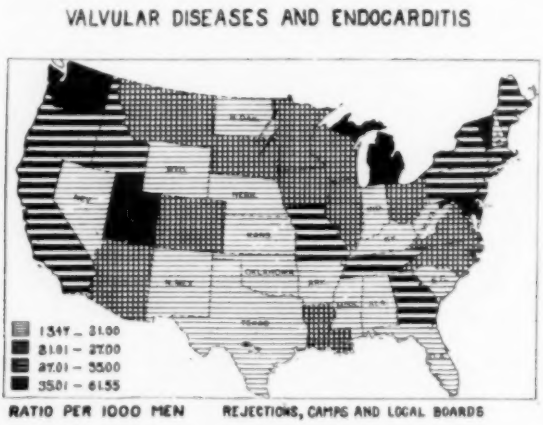



FIG. 20.

of the negro race. As for defective hearing, distribution of which is shown in Fig. 19, one sees that it reaches a maximum in the New England states. There is, however, a strikingly large amount of it west of the Rocky Mountains, and relatively little in the southern states excepting Louisiana. This exception may be associated with the fact that the French sections to be especially liable to defects of hearing.

1. *Cardio-vascular Defects.*—The statistics on cardio-vascular defects in the drafted men are not altogether satisfactory on account of the difficulty in detecting such defects under the conditions offered during examinations at mobilization camps. There were, however, plenty of defects found; about 5½ per cent. of the men examined had noteworthy defects of the valves or blood vessels. About 10 per cent. of all defects found fall

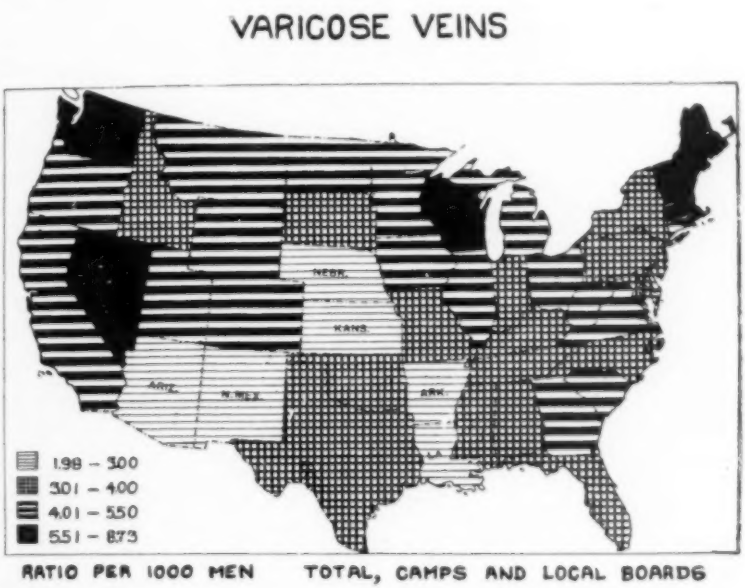



FIG. 21.

into this category. Of valvular diseases alone over 88,000 cases were recorded and of weak veins about 20,000 cases. Valvular diseases are of great importance from a military standpoint, and only about 7 per cent. of men reported having them were accepted for general military service. Of persons with varicose veins, about 25 per cent. were considered suitable for such service. The distribution throughout the United States of cases of organic diseases of the heart is illustrated in Fig. 20. Two great centers appear, one in the northeastern section of the country and the other along the Pacific coast. Where the disease rate is high in the southern states, it is probably to be associated with the negro population and to some extent with its high infection with venereal disease. Part of the high rate on the Pacific coast is to be ascribed to the idiosyncrasies of the examiners at Camp Lewis, who recorded as defective an undue proportion of men with slight heart murmurs.

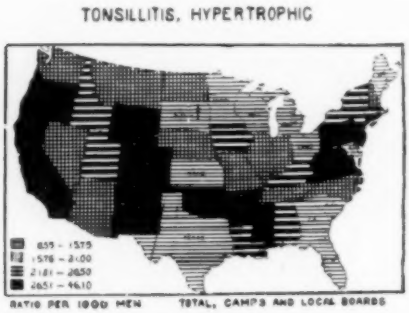



FIG. 22.

The distribution of varicose veins is shown in Fig. 21. On the whole, this condition is much commoner in the northern states than in the southern and it is found especially in the zone extending from Lake Michigan to the Pacific coast. This is a region of large men belonging to tall races and it is known that these suffer from varicose veins more than do shorter men.

18. *Throat and Nose.*—This highly vulnerable region of the body was found diseased in 65,000 men, few of whom were, however, rejected on this account. The principal trouble was enlarged, inflamed tonsils. The distribution of this condition is shown in Fig. 22. The condition is sometimes ascribed to severe climatic conditions, sometimes to overheated houses, again

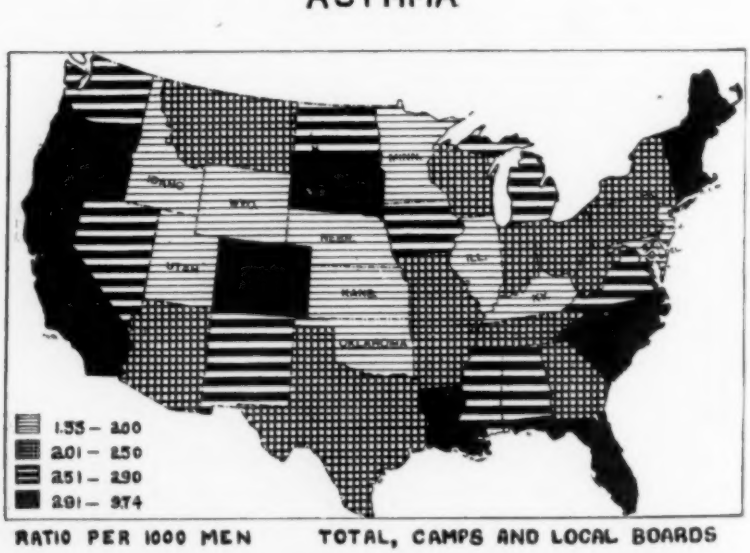



FIG. 23.

to mechanical irritations like the dust of great cities and of the desert, and again to syphilitic infection. The significance of variations in incidence of tonsilitis in the United States is not clear. It is slightly commoner in cities than in rural districts. The variations perhaps depend in part upon the idiosyncrasies of the examiners at the different camps.

19. *Respiratory Defects (Non-tubercular), especially Bronchitis and Asthma.*—Of non-tubercular respiratory defects, there were recorded over 10,000 cases, chiefly asthma. The distribution of asthma is shown in Fig. 23. As will be seen, its distribution is highly irregular. It is found especially in the

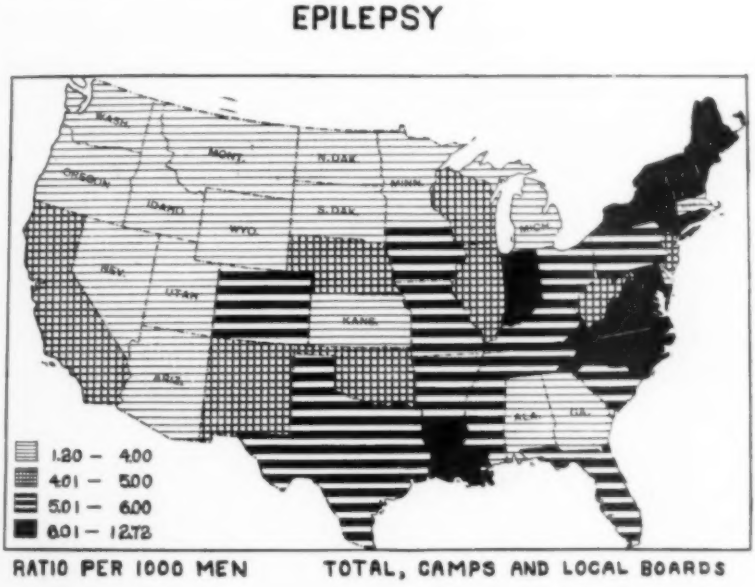



FIG. 24.

north. The entire New England states are involved and the Pacific coast is one of high incidence of the disease. It is fairly common in the black belt of the south. French-Canadians show it more than others, but beyond this there is little evidence that any special race is especially susceptible to or immune from it.

20. *Nervous and Mental Defects.*—To this great group there were assigned about 6 per cent. of the defects found, giving a rate of 33. The two commonest types were epilepsy and mental deficiency. There were over 14,000 cases of epilepsy, giving a rate of 5. The disease is especially prevalent in rural districs, probably in consequence of the greater amount of inbreeding there. The distribution of epilepsy by states is shown in Fig. 24.

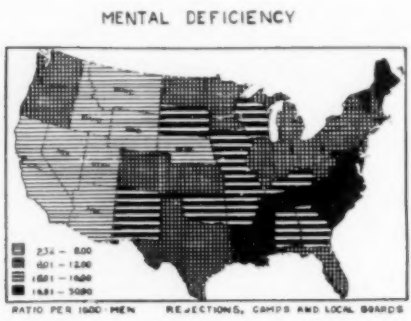
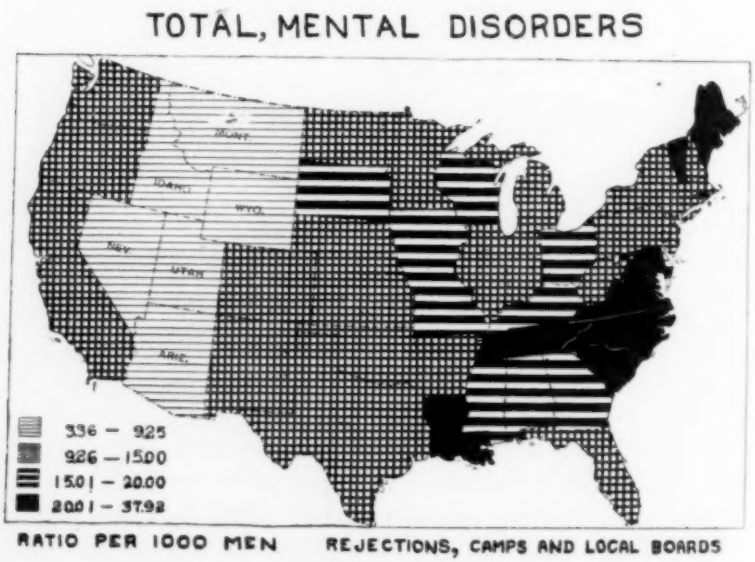



FIG. 25.

It appears at a glance that it is commoner in the older-settled parts of the country, New England, New York, Virginia, North Carolina and Louisiana. The northwest is relatively free from it, and this is no doubt due to the immigration of persons without the defect to the west and to the outmarrying that has occurred there. For it is well known that inbreeding of epileptic stock increases the incidence of the defect in the population. The disease is especially common in the districts where there are many French-Canadians. It is probably widespread among the French as a race, which may account for the high rate in Louisiana.

Mental deficiency was recorded in about 40,000 cases, giving a rate of 14. This does not give a complete picture of the



amount of mental deficiency of men of military age, because still additional cases were later discovered by the method of psychological examination. Mental deficiency, like epilepsy, is especially common in rural districts. The map of its distribution is given in Fig. 25 and Fig. 25*a*, which show that it is especially common in older-settled parts of the country and there is more of it in the southern states than in the northern. This excess in the south is, of course, largely due to the negro race. The comparative absence of mental deficiency in the west is doubtless due to the fact that few mentally defective persons have immigrated there. The commuter group contains the lowest rate among the occupational groups, while the mountain whites comprise the highest. One of the surprising results of the draft examination is the large amount of mental deficiency and backwardness among the southern Allegheny Mountains.

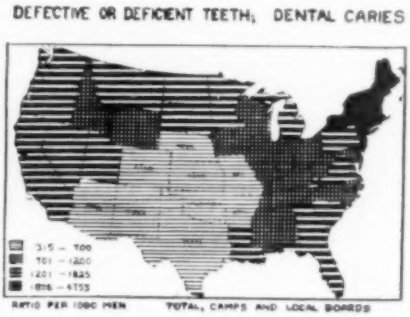



FIG. 26.

21. *Teeth.*—Defective teeth are noted in 37,000 men. It is clear that only the grosser defects were recorded. The recorded defects were indeed so gross as to lead to rejection in about 70 per cent of the cases. It is clear that the requirements for Army life are higher than those for civil life. The distribution of defective and deficient teeth is shown in Fig. 26. The one great center for defective teeth is the extreme northeast, including the New England states, New York and New Jersey. The second center is in the northwest, including states next to the Canadian border and those on the Pacific slope. A comparative freedom from defective teeth is found in the prairie states and those of the southwest. Defective and deficient teeth are much commoner in cities than in rural districts, despite the better provision for their care in the cities. This may be in part due to conditions, but it has more probably chiefly a racial significance. There is a large amount of defective teeth among the

colored people (despite a high natural resistance to dental caries among full-blooded negroes) and there is probably a racial lack of resistance in the old English stock that settled New England. On the other hand, the sections largely occupied by Indians and Mexicans show an exceptionally low rate of defective teeth, while those sections largely occupied by French-Canadians show the highest rate.

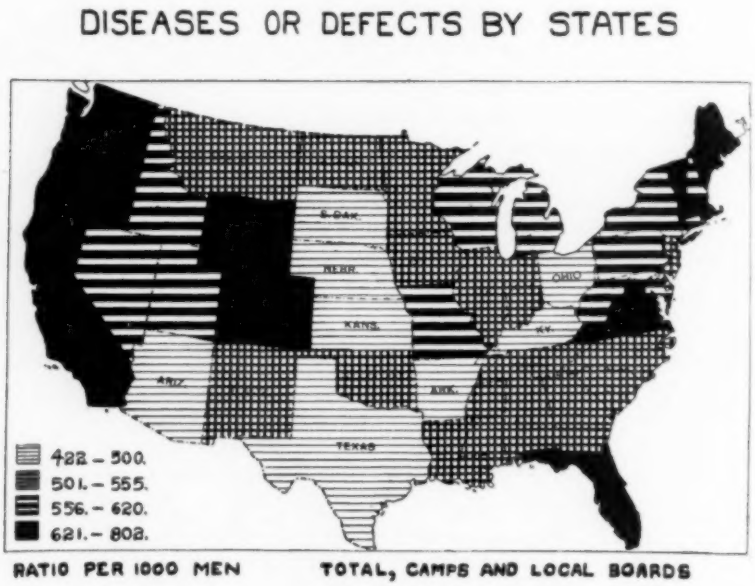



FIG. 27.

## IV. COMPARISON OF INCIDENCE OF TOTAL DEFECTS IN THE VARIOUS STATES

The distribution of total defects and diseases in the different states is shown in Fig. 27. Also detailed ratios are set forth in Table 1. There are two great centers of defect—one is in the northeastern part of the United States, and the other in the western half, including especially the states on the Pacific coast and the two mountain states of Wyoming and Colorado. Of all states Rhode Island leads with a defect rate of 802. This high defect rate, like that of the other New England states, is largely controlled by flatfoot and hernia. In the case of Rhode Island, however, many minor defects find here the maximum or nearly the maximum ratio. Conditions in which Rhode Island stand first or second are: Alcoholism, obesity, neurosis, total for myopia and defective vision (cause not stated), hemorrhoids, bron-

chitis, deformities of appendages and trunk, atrophy of muscles of the extremities, underheight and underweight. The reason why Rhode Island stands at or near the top in many defects is largely because of the defective or non-resistant stock which has been drawn to this, the most urban of all states—that in which the population is most generally engaged in manufacturing. While one may not ascribe the defects to the occupation, it is probable that the relatively low-grade, ill-paid occupation has attracted a stock with inherent defects or susceptibility to disease.

Next to Rhode Island stands Vermont with a defect rate of 764. It is surprising in what a number of defects the small state of Vermont leads. The reason for this is probably the presence of a large number of French-Canadians, in whom the defect rate it particularly high. The third state in the list is Virginia with a defect rate of 734. This state, one of the first settled in the country, apparently suffers in part from its age and consanguineous matings and in part from the nature of its colored population. Virginia stands among the first six states in the following defects: Speech defect, deafness, mental deficiency, mental alienation, sinusitis (or inflammation of the cavities of the head), enlarged tonsils, hypertrophied or dilated heart, cardiac arrhythmia (irregularities of the heart), tachycardia (rapid heart), total for hernia and enlarged inguinal rings, mal-union of fractures of upper and lower extremities, hammer toe and hallux valgus, pronated foot, pes cavus (contracted foot) and foot deformities not specified, metatarsalgia (painful foot), bullet or other recent wounds, and grand total for me-

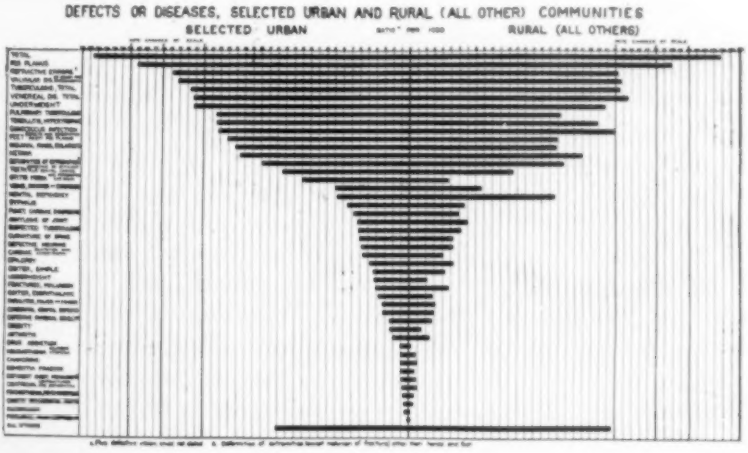



FIG. 28.

chanical defects. Many of these defects are congenital, such as arise in a highly inbred population. Others seem to be due to bad conditions of living, such as are associated with mental defect. Another large number of them is due to infection with the microorganisms of venereal disease.

At the bottom of the list stands the state with the lowest defect rate, Kansas, in which there were 422 per 1,000, only a little more than one half the defect rate for Rhode Island. Near the bottom of the list stand South Dakota, Nebraska, Kentucky, and Arkansas. These are states which have received a small amount of the more recent immigration from southeastern Europe. They are prevailingly white agricultural states (except certain parts of Arkansas, which has a rather high colored rate). This list, however, serves to warn that the influence of camp examiners has a considerable effect upon the final ratio and it is to be kept in mind that Kansas, Nebraska, South Dakota men were all examined at Camp Funston, while men from Arkansas were examined at Camp Pike. At both these camps there is reason to believe that the physical examinations were somewhat inferior in quality, so that the proportion of defects recorded to defects in registrants was less than in many other camps. This inferiority in the examiners is, however, much more striking in the case of Pike than in the case of Funston; and we must believe that the comparative freedom from defect in the states lying just east of the Rocky Mountains from South Dakota to Texas corresponds to a real physical superiority.

Since not all defects are causes for rejection, there has been made a separate table, No. 3, showing the distribution of causes of rejection by states. Here also Rhode Island stands at the top with a ratio of 424. This implies that perhaps 40 per cent. of the registrants examined in Rhode Island had to be rejected for all military service. Considering the distribution of rejections as shown in the table, it will be noted that they lie chiefly along the Atlantic and Pacific seaboards and are relatively uncommon in the interior of the country, particularly west of the Mississippi River. The New England states, New York and Michigan show a high rate for rejection. There is a considerable amount in Georgia and Tennessee (both examined at Camp Gordon), a large proportion from California and Washington, partly due to tuberculosis in the first case and various injuries in the second, and also in Louisiana. In the states west of Mississippi, however, we find low rejection rates, such as in Wyoming where less than 13 per cent. of defects found were cause of rejection.

Similar results were obtained in Nebraska, Kansas, Arizona, Montana, Arkansas and North Dakota; the inhabitants of these states are clearly a relatively physically fit lot. They represent a selection of the most vigorous of our population. On the other hand, the east seaboard has suffered by the loss of these fine young men who have migrated to the west, while those who are physically defective have more largely remained at home in the east. Also many immigrants of physically less fit stock have remained near the ports at which they have arrived from Europe, while representatives of the physically better developed races have migrated west.

For the purpose of securing populations of greater homogeneity, some of the larger of the forty-eight states were divided into two or more sections. The defect rates for these sections are often more varied than those of the states. The highest rate found outside of the state of Rhode Island is Section 5 of Colorado, which is the city of Denver. This had a rate of 800. This high total rate comprises certain large separate rates like the following: Tuberculosis 122, defective vision 35, hypertrophied tonsils 27, hernia 49, flat foot 184, and underweight 40. The lowest rate of any section is Section 1 of Kansas, which includes a strip along the Arkansas River in western Kansas. Here the rates for the diseases which we picked out in Colorado for their great size appear relatively small: Tuberculosis 12, defective vision 19, hypertrophied tonsils 12, hernia 18, flat foot 104, and underweight 1. Thus, it is seen that the reason why Colorado has such a high defect rate is because of the higher rate for tuberculosis, underweight, hypertrophied tonsils and flat foot, all of which may be dependent on infection with *Bacillus tuberculosis*, whereas the low rate for Kansas and Nebraska is due to the low rate in these conditions as well as in some others. In the case of Rhode Island, which has even a higher defect rate than Section 5 of Colorado, namely of 802, the tuberculosis rate is small, 21, and the rate for flat foot is only 117, but, on the other hand, many of the rates for the selected defects are larger than in Colorado and there are many others which have a high defect rate in Rhode Island. Thus, defective vision has a rate of 57; underweight 93; mental deficiency 16; valvular lesions 34; bad teeth 42; underheight 12. Thus, the high rate in Colorado is primarily a high rate due to the selective gathering there of persons affected with latent or active tuberculosis, while the high defect rate in Rhode Island is due to small size and a number of defects indicative of poor

stock and poor conditions of life. All fluctuations in defect rates of the different sections have in this way a meaning; but it is impossible to discuss the variations in this paper.

*Consolidation of Similar Sections.*—The 156 sections were brought together into 22 groups. These fall into three series, an agricultural series, a physiological series and a racial series. For the different groups the ratio of defect found varies considerably. Thus, in the northern agricultural groups, it is about 530, in the white agricultural group of the south, 520, in the negro agricultural group, 500, in the eastern manufacturing group the rate rises to 590 while the commuter group has a ratio of less than 540. In the mining group the rate is 569, in the sparsely settled group of the southwest it falls to 470. In the desert group, including among others, Nevada, Arizona and New Mexico, the rate is relatively high, 670. This is largely because of tuberculosis, underweight and flat foot. In the maritime group the rate is 685; in the mountain group, 570; in the sections occupied largely by Indians the rate is relatively low, 530; and still lower in the Mexican section, 470. The "native whites of Scotch origin" is a name applied to a group comprising two sections, with a rate of 473. Of the remaining areas in which one race constitutes over 10 per cent., Russians have a rate of 590; Scandinavians of 543; the Finn section a rate of 520; the French-Canadian section a rate of 684. Finally, there are three groups of German, Scandinavians and Austrians combined in various proportions in which the rates run between 510 and 540. Thus, of all the agricultural groups the rate is lowest for the negro group. In the occupational series it is highest in the manufacturing group. It is remarkably high in the desert group on account of tuberculosis and throat diseases. It is low in the groups containing a large proportion of Finns, Russians and Scandinavians, still less in the sections containing a large proportion of Indians and Mexicans. Too much stress must not be laid upon the totals. Of interest, however, is the comparison of the relative frequency of the particular diseases in each group.

The occupations play a rôle in the distribution of defects. Bad postures at school, especially in the badly nourished and rickety, account for much of the curvature of the spine, and this is developed especially in the cities; standing in shops and walking on pavements in tight shoes account for many of the bad feet of city folk. Much school and clerical work tend to induce myopia in those so disposed. Probably dust, other irritants and uncleanliness of crowded quarters favor nose, throat

and ear inflammations in those predisposed. Straining the body by heavy work induces hernia; mill work in the south and lumbering in the north causes loss of upper extremities; lumbering and saw-mill operation cause loss of fingers and arms and railroading causes injury to legs. Agriculture is associated with good eyes, straight backs and in the south (but less in the north) with freedom from flat foot and distorted toes. The eastern manufacturing group is characterized by an excess of myopia, valvular diseases of the heart, speech defect, bad teeth and underweight. On the other hand this group has a small amount of hernia and blindness of one eye. The commuter group is characterized, like the eastern manufacturing group, by myopia, also by an excess of otitis media; but the rate for tuberculosis and mental defect is exceptionally low. The commuter group represents the physically fittest of the population of the eastern section of the country. The group containing a large proportion of mining population is characterized by a fairly high rate of venereal diseases and by much tonsillitis, but relatively few cases of underweight.

Of the agricultural groups the negro sections are characterized by an abnormally high amount of venereal disease and its sequelæ, such as valvular heart disease, arthritis and ankylosis, by hemorrhoids, by poor emotional control, including tachycardia, hysteria and psychasthenia, by relatively little otitis media, deafness and defect of vision (though by much blindness of one eye), by little diabetes, spinal curvature, cryptorchidism, flat foot, and by many bullet and other wounds.

The Scandinavian sections are characterized by a slight amount of venereal disease, by relative freedom from hallux valgus and by much flat foot and by a tendency to hernia. The German groups are characterized by neurasthenia, psychoneuroses, and various psychoses, but by relatively little mental deficiency; by an excess of myopia and curvature of the spine. The French-Canadian group shows an extraordinary excess of various important defects, such as tuberculosis, spinal curvature, deaf mutism, mental deficiency and psychoses, refractive errors, otitis media, defective hearing, asthma, bad teeth, hernia, deficient size of chest and underheight and underweight. The sections of which the French-Canadians form a predominant factor are among the poorest from the military standpoint.

The groups occupied largely by Indians and Mexicans are characterized by a large amount of tuberculosis, venereal disease, and ankylosis and a low rate of valvular diseases of the heart and deformities of the hand.

The mountain whites constitute a sub-race of the whites occupying the southern Allegheny Mountains. They are characterized by an exceptionally high proportion of mental defect and mental disease, by varicose veins, by numerous deformities of the extremities and by underweight.

Various physiographic regions differ in their characteristic defects. We may distinguish the maritime, mountain, desert and sparsely settled areas. The maritime district, apart from the great cities, includes a high defect rate for venereal disease, for various nervous and mental diseases, myopia, valvular diseases of the heart, myocarditis, arteriosclerosis, flat foot, hallux valgus, deficient teeth and underweight. This group is largely influenced by conditions in the parts of Virginia bordering on Chesapeake Bay, as well as in the peninsular regions throughout the north. There is, on the other hand, a comparative absence of goiter and drug addiction.

The mountain sections, on the other hand, are characterized by goiter, deficient vision, valvular diseases of the heart, acquired defects and bad teeth, while there is relatively a small amount of tuberculosis, venereal disease, myocarditis, tonsillitis, arteriosclerosis and deaf mutism.

The desert region is characterized first of all by tuberculosis (due to the use of this region as a sanitarium), by hernia, trachoma, and flat foot and by a small amount of myocarditis, defective speech and bad teeth. The sparsely settled regions of the northwest, outside of the desert territory, are characterized by high rates of goiter, hernia, flat foot and deformities of the hand resulting from accident. On the other hand, there are low rates for nervous and mental disease, for eye defects, otitis media and underweight.

These results are not to be interpreted as indicating merely the effect of conditions upon physique; they are largely controlled by the constitution of the populations which have selected these regions as homes.

*Comparison of Rural and Urban.*—The whole country has been divided state by state into rural and urban districts. The statistics reveal a rural rate of 528 and an urban rate of 609. Thus, the selected cities showed about 15 per cent. more of defects than did the rural districts. This excess of urban defects is largely determined by the excess of flat feet, which amounts to a rate of 25. There is also in the cities an excess of underweight, inflammation of the middle ear, errors of refraction, goiter, pulmonary tuberculosis, defective teeth, and syphilis.

These defects, in which the city rates surpass the rural rates, are, however, partly counterbalanced by the greater amount in rural districts of mental deficiency, deformed and defective extremities, blindness in one eye, arthritis and ankylosis and gonococcus infection. Thus, while the urban districts exceed in the defects due to inferior stock and bad environmental conditions, the rural districts exceed in hereditary congenital defects (partly due to the fact that many congenital defects increase in the population in consequence of consanguineous matings, which are commoner in the rural districts than in great cities) and to accidental injuries (also in the amount of rural negro gonorrhea). The relative incidence of various defects in urban and rural districts is shown graphically in Fig. 28.

Thus, in summary, the northeastern part of the country appears to be characterized by congenital defects and those of city life. The northwest is characterized by deformities due to accidents, by goiter and by flat foot. The southeast is characterized by venereal diseases, hookworm and similar complications, including blindness of one eye, arthritis and ankylosis, underweight, mental defect, emotional disturbances, by pellagra, hernia, loss of upper extremity, and bullet and other wounds. The southwest is characterized by tuberculosis, drug addiction, hypertrophied tonsils and hernia. The northern central area is contrasted with the southern central by having more goiter, less tuberculosis, much less venereal disease, more varicocele and more varicose veins, more valvular disease of the heart and cardiac hypertrophy and dilatation, more deficient teeth, more psychasthenia and constitutional psychopathic states. It is characterized by more otitis media, errors of refraction, diabetes, curvature of the spine, defects of genitalia and weak feet, but less epilepsy, blindness of one eye, pellagra, loss of upper extremity, bullet and other recent wounds, underweight and deficient chest measurement. From a military standpoint the northwest contains the best men of the country.

# TONE COLOR

By Dr. T. PROCTOR HALL

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AT ordinary temperatures, waves of sound in air advance at the rate of 340 meters (1,120 feet) per second. By wave-time is meant the time of advance from a given position to the position of the preceding wave. It is recognized by the ear as the pitch of the tone. Wave-length, the distance between the crests of two consecutive waves, is the product of the velocity and the wave-time. The wave-length of audible sounds in air varies from one centimeter for the highest to twenty meters for the lowest note. Sounds whose wave-lengths are less than a centimeter are not heard by human ears. Sounds with waves longer than twenty meters are heard as a series of beats, but not as a continuous note. The wave-time of middle C on the piano is 39 ten-thousandths of a second.

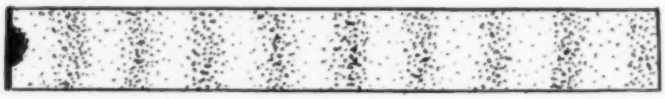

FIG. 1. DIAGRAM OF A SOUND WAVE IN AIR. Wave-length, one centimeter. Wave-time, 0.3 ten-thousandths of a second.

The loudness of the sound depends upon the amount of energy contained in its wave. For waves of a given pitch and quality this increases with the amplitude, that is, with the extent of motion of the air-particles during the passage of the wave.

Sound waves are impressed as up-and-down indentations on a graphophone cylinder or an Edison disk, and as side-to-side wavy grooves on the ordinary disk of a gramophone. They are conveniently and clearly represented on paper as up-and-down waves proceeding from left to right, in which the down part of the wave indicates compression and the up part expansion of the air.

The simplest form of a wave is the sine curve (Figure 2). Its tone is smooth and clear, like the tone of a tuning fork or a flute. Many instrumental waves are compound sine curves,

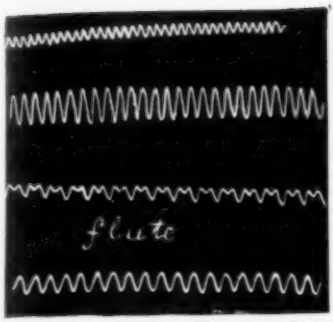


FIG. 2. FLUTE WAVES, ENLARGED FROM A GRAPHOPHONE RECORD. Magnified vertically 2,000 times. Each line is made by a single note.


FIG. 3. VIOLIN WAVES, × 2,000.

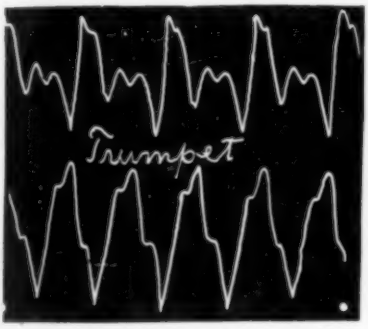


FIG. 4. TRUMPET WAVES, × 2,000.


FIG. 5. WAVE FROM A LOW NOTE OF A TROMBONE. The whole curve between the sharp upper points is a single wave. × 2,000.


FIG. 6. PIANO WAVES, × 2,000. The first two lines are two successive tracings over the same wave-record, given to show the degree of accuracy of the enlarging machine.

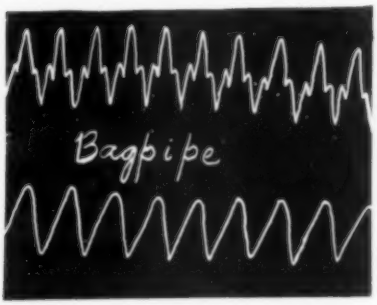


FIG. 7. BAGPIPE WAVES. The upper line, like the third line in figure two, shows a compound note. × 2,000.

consisting of a fundamental long sine wave, to which are added shorter sine waves whose lengths are submultiples of the first. The form of these compound waves gives to each instrument its characteristic timbre or quality, by which, for example, the note sounded by a violin is distinguished from a note of the same pitch and loudness made by a cornet.

Notes sung by a human voice differ radically from such instrumental notes, in that their smaller superposed waves have no fixed ratio to the fundamental wave. In the voice the fundamental wave, which decides the pitch of the vocal note, is produced by a rapid succession of puffs of air forced from the lungs through the slit between the closed and stretched vocal cords.

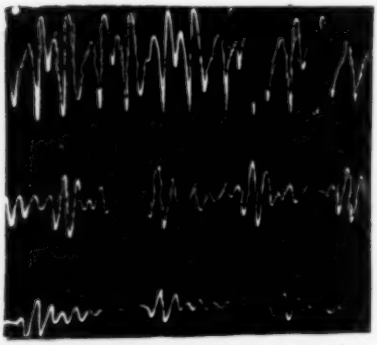

FIG. 8. THE SOUND OF *a* IN HAT, ×2,000. The upper line shows 5 or 6 wave groups, of moderate pitch; the second is a low note; the third very low, with long wave groups.

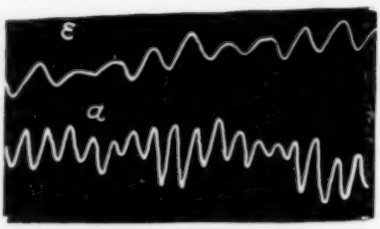


FIG. 9. THE LOWER LINE SHOWS A VERY LOW NOTE OF *a* IN HAVE: THE UPPER A LOW NOTE OF *a* IN MADE. ×2,000.

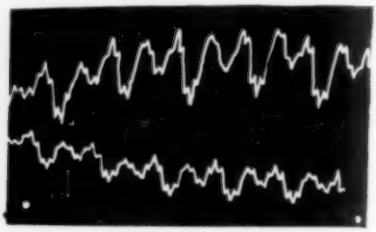

FIG. 10. WAVES OF *ee* IN DEEP. ×1,200.

Tightening the cords increases the rate of the puffs and therefore raises the pitch. Following each puff the air in the throat, nose and mouth is thrown into more rapid oscillation, like the air in an organ pipe; and these smaller resonance waves, which are added to the pitch wave, are the source of the different vocal qualities. Vowel quality, for example, depends on the lengths of the resonance waves present. The short sound of *a*, as in "hat," has a resonance wave-time of 14 ten-thousandths of a second. The long sound of *a*, as in "made," has 24 ten-thousandths. The sound of *ee* in "deep" has two resonance waves; one whose wave-time is 1½, the other 20 or more, ten-thousandths of a second.

The term tone color is sometimes used to express timbre, or tone quality of any kind. I propose to restrict its use here to that kind of tone quality which is independent of the form, amplitude, time, or length of the wave.

The tone colors of the notes of the diatonic scale have been variously described. One set of descriptive words is so selected

as to begin with the same letters as the names of the notes to which the words apply. Another set is similarly related to the letters on the staff in the scale of C.

| | | | |
|---|---|---|---|
| do′ | defiant | C′ | Clearness |
| ti | trying | B | Brightness |
| la | lurid | A | Adversity |
| so | strong | G | Gladness |
| fa | fateful | F | Faith |
| mi | mild | E | Ease |
| re | rousing | D | Desire |
| do | dauntless | C | Constancy |

These diatonic colors were personified by a young lady teacher, for the benefit of her younger pupils, in the story of

THE DO FAMILY

When they receive visitors at their home by the C the members of this family always sit in a row in their parlor. First comes Father Do, next to him a husky boy Re, and his little sister Mi. Beside Mi sits her melancholy brother Fa, and next to him the big brother So. Grandma La comes next and helps to look after Baby Ti, who always keeps close to Mother Do.

The diatonic colors whose nature is suggested by these various expressions are unchanged by a change of the key. It follows that they are due to the relation that each note bears to the key note. What this relation is will now be shown.

A stretched string or a column of air vibrating as a whole gives out its lowest or fundamental tone. If it vibrates as two separate halves the note is an octave higher and the wave-time is one half as great. If it vibrates in three equal lengths the note is *so* in the next higher octave, and the wave-time is one third. Proceeding in this way we obtain a series of notes from which a selection is made to form a "natural scale." The notes of the diatonic natural scale have the wave-times and wave-lengths, relative to the lowest note, given in the first line of fractions below.

| do | re | mi | fa | so | la | ti | do |
|---|---|---|---|---|---|---|---|
| 1 | $\frac{8}{9}$ | $\frac{4}{5}$ | $\frac{3}{4}$ | $\frac{2}{3}$ | $\frac{3}{5}$ | $\frac{8}{15}$ | $\frac{1}{2}$ |
| | $\frac{8}{9}$ | $\frac{9}{10}$ | $\frac{15}{16}$ | $\frac{8}{9}$ | $\frac{9}{10}$ | $\frac{8}{9}$ | $\frac{15}{16}$ |

The second line of fractions gives the ratio of the wave-time of each note to the one before it. From this it appears that there are three kinds of intervals between the notes. Two of them, $\frac{8}{9}$ and $\frac{9}{10}$, are nearly equal; the third, $\frac{15}{16}$, is about half as great as either of the others.

If a piano or organ were tuned to the natural diatonic scale all the music played on it would have to be played in the key of C, or the intervals would not fit the music. A change of key would not be possible.

To overcome this difficulty Bach, 200 years ago, devised the Tempered Chromatic scale, in which each octave is divided into twelve equal intervals, or twelve tempered chromatic *tones*.[1] The wave-times of the several notes of this scale are found from the time of the key note by dividing repeatedly by the twelfth root of 2 (=1.0495).

The following table shows the relation of these notes to each other, and also to the notes of the natural diatonic scale. It will be seen that *do, re, fa* and *so* are practically identical in the two scales, and that the difference of wave-time for *mi, la* and *ti* is in each case less than one per cent.

| Diatonic Natural Scale | | | Tempered Chromatic Scale | | |
|---|---|---|---|---|---|
| Note | Ratio to Keynote | | Tones Above Key | Ratio to Key | Approx. Simple Fraction |
| do′ | 1/2 | .5 | 12 | .5 | 1/2 |
| ti | 8/15 | .533 | 11 | .530 | 9/17 |
| — | | | 10 | .561 | 9/16 |
| la | 3/5 | .600 | 9 | .595 | 3/5 |
| — | | | 8 | .630 | 5/8 |
| so | 2/3 | .667 | 7 | .667 | 2/3 |
| — | | | 6 | .707 | 12/17 |
| fa | 3/4 | .750 | 5 | .749 | 3/4 |
| mi | 4/5 | .800 | 4 | .794 | 4/5 |
| — | | | 3 | .841 | 5/6 |
| re | 8/9 | .889 | 2 | .891 | 8/9 |
| — | | | 1 | .944 | 17/18 |
| do | 1 | 1.000 | 0 | 1.000 | 1 |

The strongest note, *so*, of the diatonic scale bears the simplest time-ratio, $\frac{2}{3}$, to the key note. The note next in strength, *fa*, has the ratio, $\frac{3}{4}$, next in simplicity. The most complex ratio, $\frac{8}{15}$, belongs to the note *ti* whose tone color is irritation or unrest. Next to *ti* is *re*, $\frac{8}{9}$, whose tone color is stronger, but partakes of unrest because of the psychic effort required to appreciate the element of harmony in the ratio of 8 to 9. Evidently the diatonic color of each note of the scale is determined by the ratio its wave-time bears to the wave-time of the key note. During a melody the key note is subconsciously borne in the memory, and each note that is sung is subconsciously compared with it. A change of key makes a corresponding change in the note of reference and shifts the diatonic colors to the new position of the scale.

[1] Musicians still persist in calling these intervals "half tones," which is as foolish as it would be to call the unit of length a "half meter."

The diatonic color of a note is therefore determined by the interval between it and the key note. It is evident that any interval between successive notes of a melody must in the same way produce in the second note a tone color, which I shall call melodic color. The melodic color of a note may be stronger than its diatonic color and may either reinforce, modify, neutralize, or even reverse the diatonic color. Melodic colors occur in all possible chromatic intervals, and all these intervals are found between notes of the diatonic scale. The following table gives the tone color of each chromatic interval, the words being suggestive rather than exactly descriptive.

| Note | Interval | Tone Color |
|---|---|---|
| do | 12 | Boldness, defiance. |
| ti | 11 | Suspense, restlessness. |
| | 10 | Awe, dread. |
| la | 9 | Apprehension. |
| | 8 | Pleasure. |
| so | 7 | Brilliance. |
| | 6 | Strangeness. |
| fa | 5 | Depth of feeling. |
| mi | 4 | Agreeable mildness. |
| | 3 | Sorrow, depression. |
| re | 2 | Anger, resentment. |
| | 1 | Irritation. |
| do | 0 | Confidence, rest. |

Melodic color exists not only between the successive notes of a melody but to some degree between any two of its notes. The accented notes form, by themselves, through their diatonic and melodic colors, a skeleton which expresses the stronger characters of the melody. The color of a musical phrase may be so pronounced that its essential character is retained in various positions on the scale. Here are the endless possible combinations in which composers revel, guided by a sense of feeling, often with no clear consciousness of the elements of their art.

A third variety of tone color, which may be called harmonic, arises from the relation of the upper note of a common chord to its ground note. The ground note is already in the subconscious memory in relation to the key note, and the upper note adds to its other colors some of the color of the ground note. The middle note of a major common chord is the upper note of its relative minor, and its harmonic color is that of the ground note either of the minor or of the major weakened.

| | | | | | Relative Wave-times | |
|---|---|---|---|---|---|---|
| Tonic chord ..... | do | mi | *so* | | 15: 12: 10 | |
| Its relative minor.....la | do | *mi* | | | 6: 5: 4 | |
| Subdominant chord ..... | fa | la | *do* | | 15: 12: 10 | |
| Its relative minor.....re | fa | *la* | | | 6: 5: 4 | (nearly) |
| Dominant chord ..... | so | ti | *re* | | 15: 12: 10 | |
| Its relative minor.....mi | so | *ti* | | | 6: 5: 4 | |
| Dominant seventh .....so | ti | re | *fa* | | 15: 12: 10: 8½ | (nearly) |

Each chord has its own chord color, which is totally distinct from its harmonic quality, and is, speaking broadly, like the diatonic color of its ground note. The wave-time ratios are identical in the three major common chords. Their harmonic characters are therefore exactly alike. But there are differences in the ratios to the key note. These ratios are as follows. (See the table on page 146.)

| | | | |
|---|---|---|---|
| Tonic chord (and key) ..... | 1: 1: ⅘ : ⅔ | or | 15 : 15: 12: 10 |
| Subdominant chord ..... | 1: ¾: ⅗ : ½ | | 20 : 15: 12: 10 |
| Dominant chord ..... | 1: ⅔: ⅘: ⅓ | | 22½: 15: 12: 10 |

The order of simplicity of the ratio to the key note is the order of strength of the chord color.

The elements of music are three, namely,

1. Rhythm, including time and accent,
2. Melody, the succession of notes.
3. Harmony, including tone quality in general.

Of these elements rhythm is the most fundamental and was without doubt the first to be developed. It is still the most important element in popular music. The moving power of a brass band depends on the drum as much as on any other instrument.

Melody, though it comes second in the order of importance and in the order of development, has been the last to be scientifically analyzed. Tone color is the key to its mysteries.

Harmony was practically unknown before the year 1000 A.D., and most of its development has occurred during the last 300 years. Its principles depend upon the mathematical ratios of wave-times, and are well understood.

A fourth element, suggestion, belongs rather to the listener than to the music, for its effects depend upon former experiences of the listener.

Suggestion acts (*a*) by imitation, as when the rippling of water is represented on a piano, or the cry of a child on a violin; (*b*) by natural association, as when lightning is suggested by an imitation of thunder; or (*c*) by individual association, as when some experience of joy or sorrow is recalled on hearing some associated music.

The best and strongest music combines all these elements to produce the desired effects. A clear understanding of the part played by each element in musical composition will lead to a marked improvement in the music produced.

# MILTON'S IDEAS OF SCIENCE AS SHOWN IN "PARADISE LOST"

By KATHERINE MORSE, A.M.

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EGGLESTON'S "Transit of Civilization" starts with an interesting discussion of popular belief in Europe in the seventeenth century. In its literature we find much about astronomy and astrology; especially did they touch the popular imagination. Astronomy must have been a jumble of the Ptolemaic "firm-set earth" and the Copernician theory of the revolution of the spheres. Lowell speaks of Copernicanism as "the theory that has so stirred all our modern wits." It seemed to the suspicious thought of the time to smack of witchcraft; Galileo was imprisoned, Kepler was working in obscurity, and, as we read, occasionally casting horoscopes for princes. "In the best society, the sun, moon and stars continued to revolve around the earth" without gravity and with prognostics dire of diseases and divers fortunes. Astrology was a serious avocation. Comets, eclipses, and meteors were danger signals. "God governed this one little world, and logic was the only means of discovering truth." Finally the Copernican theory evolved constant proof of the correct standpoint; even the making of clocks received an impetus, and "almanacs gradually became filled with those minute calculations with which the world has since grown familiar."

At what point in this evolution of science Milton stood is indicated by the "Paradise Lost." It is probable that he was partly convinced of the truth of Copernicus's system; at least in two striking passages he shows his acquaintance with it.

One (Book IV., ll. 592–597) reveals the uncertain state of his opinion on the subject, where he states that the sun's setting in the west would be more easily explained if the earth revolved eastward. However, to be consistent with the general scheme of the poem Milton must make his "Prime Orb" roll incredibly fast to the west. Again (Book VIII., ll. 15–178), during Raphael's delightfully informal visit to the hospitable lovers, Adam discusses at length with the Archangel this debatable question of astronomy, the outcome of which discussion is later diluted for the understanding of submissive Eve. Adam per-

ceives how difficult it is to believe that the stupendous Universe revolves in one day about "this Earth, a spot . . . that better might with far less compass move." The Angel, however, is not only "affable" but discreet, as he responds that the truth is concealed by God from man and angels, and that speculations (evidently looking far down the ages) "move His laughter." As far as man's duty is concerned it is of no real consequence as to which moves. One feels here that Raphael (and Milton) inclined to the superior simplicity of the Copernican system, in spite of prudent conservatism.

The Ptolemaic theory was evidently more adapted to concentrating the emphasis of the poem on our little earth and its tragedy, whatever Milton's own scientific conclusions may have been. His was a profound mind; he had met Galileo and refers to him in Book I., l. 288, in Book III., ll. 588–590, and Book V., ll. 261 ff.; in his day the struggle between the two theories was waging; it is possible the poet was of one mind, the compact reasoner of another. His scheme in "Paradise Lost" is undoubtedly Ptolemaic. If one dare be expository in the presence of start dust and planetary whirls and the music of the spheres, the plan of the poem may be indicated somewhat thus:

Before time was, space, strangely enough, was in two divisions, the upper half Heaven, the lower Chaos—an inexpressible quagmire. At one day, however, in the annals of timeliness, a place was prepared for the outcast angels, below Chaos. We have now three divisions of "Universal Space." It was a nine-days' fall, or rather retrogression from Heaven, as angels are not subject to gravitation and had to be beaten through Space by Christ's thunders. That Space was as far as from the center of the earth "thrice to the utmost pole of the Universe" (Book VI., 1871); such is the effort of the human mind to express infinite ideas, for which there is no material language. During an ensuing nine days, while the rebel host lay overwhelmed upon the fiery lake in "restless ecstasy" of woe, Infinity is again modified (Book I., ll. 50–53). The new universe is created. Taking a pair of immeasurable compasses, "the Son" fixes their one foot far out in Chaos, and with the other describes a great circle in the void—the boundary of the new creation. Imagination rocks at the image! (Book VII., ll. 224–231). The new universe is attached to Heaven at its north pole, and at the place where an opening is left in Heaven for angelic communication. Who but a Milton would dare be thus exact in the face of infinity! Now for the Ptolemaic theory:

In this sphere the earth is the fixed center, hanging "self-balanced." Nearest earth were the seven planets including the sun and moon, Venus, and the "other wandering fires"—Mercury, Mars, Jupiter and Saturn. (These spheres according to Pythagoras and the most beautiful conception of poetic minds, moved "not without song," "each quiring to the young-eyed cherubim." Cf. also "Ode on the Nativity," stanza XII.)

Beyond the planets was the firmament, an eighth sphere, containing the "fixed stars." This was the sphere that turned from east to west in twenty-four hours, carrying with it "all the planets in their turn," which, however, had all separate motions of their own. There was also a ninth sphere, and finally a tenth, which was called the "Primum Mobile," an impenetrable shell separating the Universe from the turmoil of Chaos. In Book III., ll. 481–483, the ten spheres are enumerated, where the ambitious spirits attempt to ascend from Earth to Heaven, and are whirled aloft to the "Paradise of Fools" on the *outside* of the Primum Mobile.

This, in general, is the scheme that Milton has elaborated in his epic, first in the passage (Book II., ll. 561–565) where Satan, wandering on the dark outside shell of the universe, is attracted to the opening at the zenith, and through that beholds the whole interior; and again in the account of the creation in the magnificent Seventh Book.

The portion marked out by the golden compass from Chaos is impregnated with warmth and light and life by the Word of God. Noxious elements escape into Chaos from the lower part of the sphere. Then follows the "conglobing of like things to like" out of the "four grosser elements"—earth, air, fire, and water, as the ancient Greek philosophers considered them. Light, the fifth element, is evoked by the Creator. The sun, which Satan saw as the most splendid body in the universe, though but the fourth sphere, Milton describes as containing a large part of the light of the world, the Almighty having concentrated it there at the fiat, "Let there be light." (Book VII., ll. 359 ff.)

Milton's interpretation of the "firmament" is the reconciliation of the first chapter of Genesis with the Ptolemaic theory. The firmament separates the waters flowing around the Earth from water "diffused throughout the Universe." This He removed to the outside of the Eighth Sphere, forming the Ninth, or "Crystalline Sphere" separated from Chaos only by the Primum Mobile (Book III., ll. 444 ff.). Thus the firmament was the great extent of space between the earth and the utmost

boundaries of the eighth or visible sphere. This vast expanse was named heaven, after the greater Heaven, the abode of God. Line 176 in Book VII. ("Immediate are the acts of God") would seem to imply that Milton conceived of Creation as instantaneous, though perhaps for the sake of human limitations it is described as the work of six days.

Again in Book VIII., ll. 81 ff., occurs a very definite statement of the growth of the Ptolemaic universe by the addition of "orb after orb." Further on the poet refers to the two devices of the eccentric and the epicycle, by means of which complicated system of reasoning the Ptolemaic astronomers tried to explain why the sun's motion seems faster or slower according to the season (Book VII., ll. 82–84), in which connection it is interesting to note that Bacon himself showed his dissatisfaction with such reasoning in De Augmentis, IV., ll. 347–348, where he compares the contribution of astronomy to the human intellect to the fraud practised by Prometheus upon Jupiter.

We find Milton again wavering in Book VIII., ll. 130 ff., where the earth is said to have three motions; rotation on her axis, movement around the sun, and her "trepidation" (Book III., l. 483) during her orbit. Here is the Copernican theory; but in ll. 131 ff. Milton says, "which else" you must ascribe to the old theory that several spheres move contrary to one another with "thwart obliquities." As for the moon, it was supposed to have rain ("Her spots thou seest as clouds"), and perhaps inhabitants (Book III., ll. 145–147). "Other Suns, perhaps with their attendant moons," may be a reference to Galileo's discovery of the satellites of Jupiter and Saturn (*ib.*, ll. 148–149). It is interesting to note at the close of this passage on Milton's uncertain astronomical faith, how opposed are his to Bacon's pronouncements. Milton discourages the inductive process, "nor with perplexing thoughts to interrupt the sweet of life" (Book VIII., ll. 183–197). This is, of course, directly the opposite of all Bacon's teaching as to inquiry into the secrets of Nature with a view to solving her perplexities.

Finally in Book X. is an ingenious explanation, whether Ptolemaic or poetical, of the obliquity of the earth's axis to the ecliptic (ll. 671 ff.). "Some say" that after the Fall, God bade the angels turn the pole so that it no longer pointed toward Heaven's gate. Or else "the Sun was bid" to turn out of "the equinoctial road." At all events, Spring was thus prevented from "perpetual smile" on earth, and days and nights were made unequal.

Milton's astronomy has, I fear, been rather vaguely indi-

cated. It is, indeed, an unexampled combination of vagueness and exactitude, of material limitations and sublimity. It is less of earth than of Heaven and Hell and "Chaos and old Night." It is the conception of a soaring intellect and a blind man who sees flashing lights and geometrical shapes in the darkness.

As to his ideas of natural science, there is less to say. He held, like all his contemporaries, beliefs as to the physical influence of stars on beings of this earth. ("Their stellar virtue," etc., Book IV., l. 671.) "The sweet influences of the Pleiades" were supposed to bring gentle blessings when they were in the ascendant. In the autumn Orion brought storms "with fierce winds armed." "Comets shake pestilence and war" (Book II., l. 710). Astrology, I fancy, was a natural outgrowth of Ptolemaic astronomy. The most striking reference to astrology is in Book X., ll. 658 ff., where the "aspects" of planets is mentioned, which according to tradition were "happy and unhappy" as regards the destiny of man.

Quaint notions of chemistry occur. In Book I., ll. 673–674, Milton expresses the popular belief of the time as to the importance of sulphur. "In his womb was hid metallic ore, the work of sulphur." From Pliny to Bacon, men held that sulphur, mercury, and salt were the all-pervading substances in nature. Other minerals occur; "Naphtha an asphaltus" light the roof of Hell. Alchemy is also referred to in Book III., l. 601, and the "philosopher's stone." "They do bind volatile Hermes" evidently means the solidifying of fluid mercury.

All things need food, even angels and perfect men, "who fell upon their viands"; even elements, of which "the grosser feeds the purer"—Earth the sea, and Earth and Sea the air—they all need nutriment. The moon is fed by mud of the earth sucked up with the moisture, according to Pliny, who is here echoed by Milton: "The moon whence in her visage round, those spots, unpurged vapours," etc. "The sun receives his alimental recompense in humid exhalations, and at even, sups with the Ocean," a statement of which Landor strongly disapproved poetically. Another belief, expressed in Book X., ll. 243 ff., assumes that things "of like kind" have peculiar physical sympathy at whatever distances from each other they be—a sort of atomic telepathy. In Book X., l. 666, we find the old belief that thunder is rolled by winds.

In Milton's natural history, we are again reminded of Pliny, as where serpents "with snaky folds and added wings" are created (Book VII., l. 483). In Book IX., ll. 581–582 is an allusion to the supposed habits of serpents that loved the smell of

fennel and were said to suck ewes' udders. "The female bee," according to the belief of the day, is represented as the worker of the hive. The animals in "Paradise Lost" are all highly entertaining. Milton seems to have thought that brutes have a higher degree of intelligence than is usually attributed to them. "They reason not contemptibly," he writes in Book VIII., ll. 373–374. He alludes to the flight of cranes "with mutual wing easing their flight"—each helping the progress of the whole body by becoming in turn the point of the V. The will-o'-the-wisp he calls "a wandering fire" (Book IX., ll. 634 ff.). In accounting for this phenomenon Milton seems very modern, if we take its origin from "unctuous vapor" to mean gas from decaying swampy matter. Vultures are made to "scent a field unfought," as Beaumont and Fletcher also held in "The Beggar's Bush." This must have been a popular superstition. The different kinds of asps, scorpions, etc., in Book X., l. 524, seem to be taken direct from Pliny after the manner of natural historians of the day. Echoes are found here also of Lucan's "Pharsalia" (Book IX., l. 700).

The medical theories of Milton's day occur in various parts of "Paradise Lost," notably in that poignant passage of Book VII. on his own blindness, where he describes it as probably arising from "the drop serene" that left his eyes without blemish; yet he is not sure but that his case is one of "dim suffusion." Eye diseases were thought to arise from affections of "the humours." "Euphrasy and rue (Book XI., 1414) are mentioned as strengthening the eyes; euphrasy was called "eye-bright." The poet had possibly tried both in vain. In Book XI., ll. 477–493, occurs the famous enumeration of diseases—one sad result of Adam's fall. "Moon-struck madness" echoes another popular superstition. "In thy blood will reign a melancholy damp" is a reminder of Burton, who calls old-age "cold and dry" and of the "same quality as Melancholy." "Humours" and their baneful operations were prolific subjects for speculation in the sixteenth and seventeenth centuries, it appears.

Botany in "Paradise Lost" is interesting. What minute and loving memories of plants! Eve's troublesome vines make one think of the charming gardens described by Harrison and Sir Thomas Browne. But to one reader, at least, the most interesting observation, aside from Milton's amazing astronomy, is the detailed and accurate knowledge of geography displayed by the blind man. How minutely he remembered his maps! What marvelous surveys of geographical discoveries! What delight in sounding names! The passages are too well known to need

comment. One of the most remarkable, however, is in Book XI., ll. 385–411, where the eyes of the poet's mind glanced over all of the then known Asia, Africa, and Europe—a stupendous feat of memory, as well as an example of "the poetry of proper names." One is reminded of Macaulay's famous passage in his essay on Milton in which he describes the "long muster-roll" of "charmed names."

A striking impression that remains after a careful reading of "Paradise Lost" is the daring use Milton made of his immense knowledge—the combination of definiteness and mystery; titanic pagan angels fighting like the heroes on the plains of Thessaly, but in a definite Ptolemaic scheme; deathless beings, not subject to gravitation; Time in Heaven ("'Two days as we compute the days of Heaven' said the Almighty Father"); Satan suffering from the loss of his immortal ichor, as Mars did at the onslaught of Minerva, and modern methods of blood-stoppage applied; all of gorgeousness, awe, dignity, in a materialistic heaven with fighting angels who dig for metals to make cannon! How could any one at that time have accomplished such audacity with what are called Christian conceptions? Homer is audacious and sublime, but we call him frankly pagan. Again, in portions where exactitude of information is most evident, as in the "muster-roll of names," and in the Ptolemaic astronomy, occur some of the most transcendent passages of poetry!

The seventeenth century writers, it would seem, had an attitude of high romance toward science; at least they wrote about it poetically. (Wordsworth once said it must eventually become a subject for poetry.) Surely we find that poetic sweep of thought in Bacon with his visions of experimentation; in Burton who made a medical treatise read like a novel; in Sir Thomas Browne, whose observations on obscure researches sound like the Book of Revelation; and in John Milton, who marshaled all the hosts of his mighty mind to evolve a vision of creation out of darkness.

# SCIENCE AND SOCIAL UNREST

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THIS is the era of science. Were we unable to discover this fact for ourselves we at least would come to believe it from the constant and proud affirmations of the scientist. We are told that science has recreated the world and within a brief century. The facts are so apparent that the person least interested in science has to admit them. At every point human experience has been changed by the contribution of science and invention. Traditions have been broken. Customs have been destroyed and are being destroyed. Social habits have been modified. New motives have followed from the new conditions created by science; former motives have grown faint and are passing. Already science has accomplished beyond the dreams of human fancies of an earlier period. And the end is not yet. Indeed, science never promised more than now and was never advancing with more rapidity.

There is another fact that stands out as clearly these days as that of scientific progress. We are living in an age socially as discontended and feverishly restless as the world has known. The discontent is not, however, a hidden dissatisfaction, far under the surface and known only by the few gifted in genius for penetrating into contemporary conditions. Our social discontent is self-conscious, boastful and even blatant. It is also omnipresent and from it we can not escape. It has entered into the remote countryside and brought under its spell even the least sensitive of farm "help." It has captured the house servant and brought chaos to individualistic housekeeping and our crowded hotels to the point of bursting. Contrary to the opinion of some, it is not class movement, for it cuts across classes and is found among the wealthy just as it is among the poor. It is not in any sense national, for it appears to have swept the entire temperate zone like a rapid-moving pestilence.

If the scientist has made our era, he surely must also accept responsibility for our characteristic unrest. It may be that the world has indeed been recreated, but it has not yet been brought to a condition of safety. The scientist in the past has given

scant consideration to the social problems created by his splendid success in mechanical and industrial development. Human nature, as the war has taught us, has changed little since the time of primitive man, and during the last century with the wonderful advancement of science there has not been equal progress in human discipline or intelligence. The things that men handle have been multiplied and magnified, while man himself has lagged behind, altogether too confident that the results of material progress would in themselves bring social satisfaction and sanity.

It was a foolish assumption. To hold it now is stupid stubbornness of mind. There are some who by heroic effort still cling to it, fearing that nothing else can give a substantial basis for the idea of progress. It is, however, growing more and more difficult for any one to believe that social security will necessarily follow from the contributions science is making that enrich the material resources. The unpalatable but enormously significant fact can only be held out of consciousness by the persons who are willing to cloud the social truths if for a season they may protect their intellectual comfort from such disquieting disenchantment as would follow the admission that unrest has become the dominant social phenomenon in this age of scientific prosperity. It is becoming increasingly difficult, however, for any one to shut his eyes to the premonitory fact that stands out so clearly. A multitude of men and women are by no means socially content in this era of science; they are profoundly dissatisfied and their souls are seething with restlessness. The solid fact can not be pushed aside by refusal to recognize it.

From a social point of view science has not been as successful as the average scientist imagines. Science means more than a mere collecting of information. It is not simply a classifying in a systematic way of all the trustworthy facts known at the time. It is especially an attitude of mind and one that human nature acquires with painful difficulty. It originates, to be sure, from a universal instinct of curiosity, but the finished product contains an element of personal indifference which is foreign to the unmodified instinct. Science is the highest form of that reality thinking of which the psychoanalysts make so much and stands in sharpest contrast with their definition of the easy-going pleasure-form of thought. It is the most heroic effort the human mind can make to get rid of all personal inclination and bias in meeting an intellectual problem in order that the truth of any matter may be as accurately known as is possible. It

is in its success in putting aside personal desire that scientific thinking distinguishes itself and wins the right of intellectual supremacy. Huxley has most happily expressed this spirit of self-renunciation on the part of the scientist when he faces any investigation.

> Science seems to me to teach in the highest and strongest manner the great truth which is embodied in the Christian conception of active surrender to the will of God. Sit down before fact as a little child, be prepared to give up any preconceived notion, follow humbly wherein and to whatever abysses nature leads or you shall learn nothing.

Unscientific thinking is under no such coercive discipline, but may, if it pleases, follow hard after personal desire even though at the end one be ditched from having neglected fact for fancy.

Science has, by its superior attitude of mind, accomplished marvels and obtained a spectacular success. It has not, however, given the great mass of people any appreciation of its highest function. Science has been valued by the majority of people for its accomplishments, not for its portrayal of the advantages of stern discipline in mental experience. It has merely encouraged a vast multitude to believe that human existence is a never-ending pleasure hunt and science the best giver of material comforts and luxuries. The craving for personal gratification has been stimulated by the magic-like productions of science until an appetite has been created that nothing can satisfy. Social well-being has needed the teaching of science more than its products. The philosophy of the street admires science for its liberality in things; it turns with indifference from any attempt to popularize the self-restraining spirit of science. The scientist is welcomed as a good workman; he is ignored as a teacher.

From such a situation social sanity can not be expected. Science increases the power and freedom of men; it fails, or thus far has failed, to prepare them for the proper use of their increasing opportunities. The race with its hundred thousand years or more of stern discipline and struggle is hardly ready for the present enormous quantity of pleasures and the life-motives that are constructed in pleasure-terms. The social problem has come to be merely making life easier for a greater number of people and by some process permitting material pleasures to be equally shared.

Even if we assume that this program states the goal of all social endeavor it by no means follows that its working out is a simple matter. The problem of method still remains and here,

if ever, there is need of patient scientific investigation and experimentation. Social experience ought by this time to have taught men how complicated the details of any such program must be and how foolish it is to attempt a quick and à priori solution. Why is it one may well ask that the popular thought is so intolerant of giving to science the problem of finding a more just distribution of material wealth? The world-wide drift of population toward the cities is part explanation of the confident social philosophy that can not endure the thought of giving even so delicate and hazardous a problem over to "cold-minded" science. Urban life does not tend to teach men caution in the working out of social programs, for it is difficult in the city to have that first-hand contact with nature, which, more than any other human experience, provides the basis for moral discipline and curbs the arrogant and unreasonable demands of men and women. The city, by hiding the natural obstacles that always hamper the accomplishment of man's purposes and by turning the attention to the competition one person has with another, encourages the belief that the difficulty of obtaining one's complete happiness is due to the interferences of other people. The constant experiences of rural people with the menace of frosts, blights, insect pests and droughts impress upon them the elemental fact that nature itself is often in opposition to the purposes of men. Rural philosophy becomes by instinct suspicious of any get-right-quick social scheme.

City conditions provide the perfect opportunity for the gregarious leader, who wins his power by skill in directing urban discontent and industrial restlessness. He is by temperament unsympathetic toward the cautious experimental methods of science. Indeed he could not hold his following by a judicial attitude toward social grievances, for they follow him not for his accomplishments, but for his ability to voice in catching phrases their inarticulate discontent. Everything in the city conspires to turn this dissatisfaction into economic form. The conflict of classes, the apparent omnipotence of money to furnish the conditions of health, social standing and happiness to the well-to-do of the city and to deny them to the poor, the constant pressure of economic competition, these influences and many others of similar character all tend to magnify the value of money and to conceal the ever-present checks upon human purposes that nature will present under any form of social régime. The urban problem of life boils down to the getting of sufficient money to satisfy one's desires and it becomes the con-

viction of a multitude that their satisfactions can be increased only by placing limitations upon other people whose desires collide with their own.

Since the modern city is the creation of science, science must assume responsibility for the intense gregarious appeal that it is now making throughout the civilized world. No person, however great his indifference toward science, ever visits our greatest city without appreciating how science makes possible modern New York. The very existence of the city is conditioned by the inventions that face the visitor on every hand. Were any of the more important contributions science has made to the city's welfare to be removed or made inactive, in an hour's time the city would change from a place of business and amusement to a horrible death trap from which men, women and children would flee as from the clutches of a devouring monster.

It is folly to regard our present social crisis as merely a succession of disputes regarding wages, commodity prices and hours of labor. It is not merely based upon dissatisfaction with our present capitalistic system. In the present temper of the people no change, whether it be in industrial organization or wealth distribution, can bring cessation of social restlessness. Science has created an appetite that no governmental or industrial regime can satisfy.

The situation in which the world finds itself, which the war has hastened but not caused, resolves itself in its lowest terms to the impossibility of a people socially unscientific living a satisfactory life in a scientific era. The safe way out, the path that is likely to be chosen after painful social experiences in any case, sooner or later, is through the popularizing of the spirit of science. The task is not impossible, for any social attitude can be taught by a vigorous, determined leadership.

For the most part in the past science has been indifferent to its teaching function. Many of its leaders have been aristocratic in their conception of science and have looked askance at their colleagues who have had a mild desire to bring to the average person a taste of the sweet fruits of the scientific mind. Especially has the scientist cared little whether science was taught in the public schools or whether it was so taught as to give the developing pupil a glimmering of the methods by which science wins its conquests. College teachers of science have not infrequently dismissed the problem of high-school science with the comment that they always have found that pupils who have had no science in the high school are the best

prepared for college courses in science, refusing to accept the testimony of the students respecting the value of their preparatory courses. The vocabulary of the scientist and his manner of writing and speaking has in general been unnecessarily esoteric and he has been proud of the self-imposed limitation that has given him a class consciousness.

On the other hand, the scientist has been subservient to the ambition of commerce and never-ending effort has been made to popularize the demands for the products of science. By means of human ingenuity, by advertising propaganda of tremendous economic cost, the appetite for things has been stimulated and the concept built up that the happiness of man does consist in the abundance of the things he possesses.

Society desperately needs a democratic science. In very recent years, especially in medicine, there has been a most encouraging movement toward the socializing of science and the acceptance on the part of the scientist of his obligation as a public teacher. Medical science deserves the greatest appreciation for this splendid service carried on often against the self-interests of the profession. It is, however, not the results of science that the people need so much as its spirit of rational discipline.

The promise of social progress is in science teaching men and women with the same success that now it feeds, houses and gives them playthings.

# POPULAR MISCONCEPTIONS CONCERNING NATURAL HISTORY

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THERE is in the popular mind a surprisingly large store of misinformation and misconceptions concerning many forms of natural history. They concern not only exotic and the less well-known plants and animals, but our commonest forms share prominently in these misbeliefs in spite of the large amount of published information on natural history and opportunities for individual observation. To err is human and all classes share to a greater or lesser extent in errors of judgment and observation. But there is a large class of traditional errors that have become more or less fixed, some locally, others nationally. It is this class, a part of our folk lore, which has been perpetuated in many cases in books, magazines, newspapers and traditions with which this article will deal. It is perhaps impossible to find the origin and to trace the development of our common natural history misconceptions. It is possible by an analysis of some of our most widely known ones to assign probable explanations of their origin and by the application of certain well-known principles of human psychology to understand their perpetuation.

It should be mentioned first that the perpetuation of our traditional natural history misconceptions is made possible largely by the fact that a considerable portion of the people do little or no reading. There is also a class which reads for thrills and not for information, that may be included with the above. There is in print enough accurate information to set at naught most or perhaps all of what is commonly termed popular misconceptions. It appears that prevalence of natural-history superstitions and misinformation in countries and communities is in inverse ratio to the amount of reading done. It is perhaps true that the country people perpetuate more of this misinformation than do city people, though the difference is not so great as is generally thought.

It has been frequently stated that human nature is inherently lazy. One apparent manifestation of this is that many individuals prefer to take another's explanation of some phe-

nomenon rather than to secure the information for themselves. This is of course not a characteristic of the untutored mind alone, but college students very commonly follow this line of least resistance. This fact makes possible the perpetuation of gross inaccuracies. It is commonly stated that the earthworms seen so often crawling about after a hard rain have fallen with the rain. An observation requiring only a few minutes would reveal the holes in the water-soaked earth through which they have emerged and perhaps a few in the act of emerging.

The statements of the more prominent people in the community are more likely to go unchallenged than those from the less well known. This prevails among all classes. A very prominent early worker in entomology figured grasshoppers laying eggs in an impossible position fifty years ago. This figure has been widely copied and accepted without question until a few years ago, when it was disproven. It would have been an easy matter to check up this observation had not the prominence of the early worker given added confidence to the earlier conclusions. There are no doubt, many errors in scientific writings perpetuated because of the prominence of the writer, whereas the unknown scientist might be quickly doubted.

An acceptance of the opinions of others is most frequent when individual observations are difficult or impossible. The group of misconceptions arising in this connection is naturally a large one, since superstition, hearsay and exaggeration play important parts. It is impossible for the rank and file to follow the latest scientific discoveries explaining even most familiar phenomena, much less to investigate for themselves. Consider the following in this connection. It is quite generally believed that flies are able to walk upside down because they have suckers on their feet. This is an old idea which has persisted, largely in the popular mind, though it has long been known that there is a secretion of adhesive material from minute glands on each tarsal pad which enables the insect to literally glue itself to its sub-stratum. Again, animate objects that glow or glisten are generally said to possess phosphorescence. The best known instance is that of the lightning bugs or fire flies which are often seen by the thousands on a warm summer's evening. Recent studies apparently find no basis for this belief, but explain the light as due to rapid oxidation of certain cell substances. Less frequent perhaps is the belief that the glistening of the cat's eyes in the dark is due also to phosphorescence, when the true explanation is said to be the reflection of entering light by the tapetum, a thin membrane

covering the retina. Quite general is the belief that mad dogs foam at the mouth; in fact this is thought to be the one thing to look for when a mad dog is suspected. Published observations indicate that foaming at the mouth is not present in all cases and when present is not the first manifestation of hydrophobia. The streaks of light so often seen in summer in the west below the sun is explained as the sun drawing water. At times, it is commonly thought the sun draws with such force that the earthworms, frogs, snakes and even fish are drawn up to be dropped with the next shower.

Perhaps the majority of misconceptions concerning natural history are based on mistaken observations and misinterpretation of the facts involved. Many people arrive at conclusions quickly and an explanation that appears plausible to one is likely to appeal to others. Such misconceptions arise from new sources constantly. A beaver's tail, for example, suggests a trowel, especially when considered in connection with its houses. It is not surprising that there has arisen a persistent misconception sometimes seen in school texts that the beaver's tail is used as a trowel. Seton finds no evidence whatsoever to substantiate this belief. Its front legs and chin are its chief tools in building operations, while the tail serves chiefly as a propelling and guiding force while swimming and to "slap" the water as a signal to its associates. The beaver is said to drive stakes or piles in the mud of streams, another fallacy based on a superficial observation of the sticks and not a study of the animal. The porcupine is said to shoot its quills at its enemies because possibly of the superficial resemblance of the quills to arrows. Indeed, when a dog attacks a porcupine he invariably comes off with some quills in his flesh, which is accepted as further proof that they were shot like arrows at him. It is of course impossible for this animal to protect himself in this manner, there being no muscular or other arrangement to effect it. The quills are very loosely attached, therefore easily dislodged. They are also very sharp and readily puncture the flesh of its captor.

Some misconceptions of this class have been given prominence and perpetuated by incorporating them in the common names of the animals themselves. Flying squirrels and flying fish are familiar subjects of natural history, yet neither actually fly. The so-called flying squirrels are gliders or parachuting animals only, inasmuch as they can only descend from a higher place to a lower, using the extended skin between the fore and hind legs in the same way as a parachute is used. The so-

called flying fish appear superficially to be true flying animals for the enlarged pectoral fins suggest the wings of a bird. Yet there is no doubt that they use these fins as planes for gliding only. The propelling force is the tail which supplies the momentum before the fish leaves the water. The longest glides are made against the wind. There is no suitable musculature to effect a flapping movement. There are many available illustrations among insects where the common names involve an error of some kind. Popularly speaking, all insects are bugs when, strictly speaking, this name applies only to one order of sucking insects (Hemiptera). The larvæ of some insects are called worms when this name is more properly applied to members of the *phylum annulata*, of which the earth worm is a type. Clothing, carpets, etc., are said to be attacked by the clothes moths, yet in no case is the injury done by the moths, but by the larvæ of the moths, the former feeding on nectar or pollen and being quite harmless. The buffalo bug is not a bug but a beetle; the pear slug is not a slug, but a slug-like larva of a true insect; the sheep tick is not a tick, but a fly, etc.

It appears further that of all animals, there are more misconceptions concerning the ugly and disliked ones than others. The skunk, weasel, toad, snakes and spiders are not general favorites with the people at large; in fact they are shunned and even a distant acquaintance is abhorred. The less known about an animal, the more readily will hearsay, mistaken ideas and imaginative tales be believed. Snakes are perhaps the most widely feared and despised of all creatures. It is not surprising, therefore, that we have such fantastic stories as the hoop snake, the glass snake, the monster sea serpents, mother snakes swallowing their young in the presence of danger, not to mention the mythical scaly monsters that exhaled smoke and fire. The snake charmer makes a living by taking advantage of the lack of true information about these much abhorred creatures as well as of various superstitions and misconceptions concerning them. No circus would be complete without its dangerous snake, the largest in captivity. It is quite generally believed that all snakes and spiders are poisonous and their bites would prove fatal, when authentic accounts say there are many of both that are wholly harmless. Snakes are said to be deaf, and only last year this misconception appeared in prominent head lines on a page about snakes in a leading Sunday paper. True, there is no external ear present, but there is nevertheless a pair of ears and the old adage "as deaf as an adder" is no longer expressive. Rattlesnakes are supposed always to rattle before

striking, a kind of gentlemanly sportsmanship to warn the victim that he still has a chance. Observations recorded appear to show that the rattlesnake may forget this chivalrous act and strike without warning. The writer believed throughout youth that when a snake was killed, its tail would not die until sun down. This misconception has been met with among youths of three widely separated localities. The brain of snakes is small, consequently some powers held by the brain in certain other animals are delegated to the spinal ganglia in the snake, therefore crushing or severing the head of the snake does not remove the possibility of body movements from impulses emanating from these ganglia. Perhaps some one disliking cats started the revolting story that if a cat was left alone with an infant, it would kill the child by sucking its breath. This impossible thing is quite generally believed, though without basis of facts.

Then there is another prominent group of misconceptions bearing little semblance of truth whose origin is perhaps the work of a fertile imagination. Consider, for example, the well-known belief that a horse hair will turn to a snake. It must be a hair pulled out by the roots from either the mane or tail and kept in quiet water, we are told, and in due time it will be a snake. Thus *Gordius* and other closely related round worms which are about the same size as horse hairs are supposed to come into existence. Of course no one has even been able to effect this transformation, because he failed to follow directions carefully. The earwigs (Forficulidæ), relatively common insects in Europe, are so named because they are supposed to puncture people's ears. This reminds us somewhat of the very general belief in the United States that dragon flies sew up the ears of bad boys with their long abdomens which superficially suggest a stout needle. But one of the best examples of this class is the well-known supposed performance of the "doodle bugs," more properly known as ant lion larvæ (Myrmeleonidæ). These larvæ make little pits in sandy places and wait concealed, except for the protruding jaws at the bottom of the pit, for ants. The story goes that when a pit is found, if one repeats the following couplet, the hidden larva will immediately leave its pit and pass in review before the observer. One version is, "doodle bug, doodle bug, fly away home; your house is on fire your children will burn." There are various modifications of this charm in different localities. This is one of very few instances where a lowly insect is credited with "knowing" its name.

There is a difference in the misconceptions about objects of

natural history in different localities thus introducing some interesting variations. The writer had this forcibly brought out in several communities by the various popular rules to follow for determining which mushrooms were edible and which were poisonous. In one community, those that were pink underneath were regarded as edible by some collectors, in another community these were discarded as poisonous. The same divergence of opinion was observed with the rule that if they would peel they were edible and with those growing on wood. In one community to find water with a forked stick, a peach twig had to be used, elsewhere cherry or willow was always used. One finds a host of examples of local differences in superstitions. In some homes the chirp of a cricket in the house is regarded as a "good sign," in others fortelling disaster. Likewise the screech owl in some communities is supposed to foretell by its plaintive song evil happenings, at other places, announcing good news. In some communities killing a toad will cause all the cows in the neighborhood to give bloody milk, elsewhere robbing a robin's nest will effect the same result according to the superstitious folk. The crowing of the cock before midnight is in some places the herald of rain the next day, elsewhere it merely announces a visitor.

The chief importance of a consideration of these and other misconceptions of natural science, excluding the student of folklore, is their effect on the youth. These mistaken ideas become fixed in the minds of children, perhaps when very young, and will persist until corrected. Classes of fifth-grade children in the public schools of Milwaukee invariably stated that the ostrich in the presence of danger buried his head in the sand, and immediately felt safe, on the principle that if he could see no danger there was no danger. Perhaps seventy-five per cent. would uphold this idea. This explanation has persisted with the public generally and can be found in many books at the present time, notwithstanding reliable observers report this to be fallacious. In the writer's community it was almost universally believed that dragon flies were snake doctors whose chief duty it was to heal sick and wounded snakes. This supposed duty was the source of considerable prejudice against these beneficial creatures, and we therefore killed them at every opportunity. Likewise the barn swallow was killed and its nests destroyed whenever possible, for it was supposed to carry bed bugs.

Children are told these things by parents, servants, playmates or neighbors and in rare cases in the elementary schools.

Their confidence in these people causes them to believe them unreservedly. In many homes, especially where little attention has been given to scientific facts, boys and girls gather together a surprisingly large store of mistaken ideas and misconceptions about natural history before reaching school age. This fact is all the more significant when we recall that, for most of us, it requires more effort to correct a mistaken idea than to learn a new one. The daily and Sunday newspapers have a share of the responsibility for some of the misconception in this connection. In their effort to present the unusual and supposed revolutionizing discoveries, the truth is sometimes handled recklessly. Furthermore, purported scientific observations made by correspondents and others are often misleading. Aside from the uselessness and burden of mistaken information, there is an important practical and economic aspect to this subject. The individual may be made to fear or despise a truly beneficial creature and to kill it at every opportunity for reasons based on errors. Which creatures are beneficial to man and which are harmful are, after all, too important considerations to be based on errors.

Let these truths be added arguments for the serious and efficient teaching of nature study in the public schools, for if popular misinformation about well-known objects of natural history is ever corrected, it will be largely through the initiative and intelligent direction of the schools.

# THE MECHANISM OF EVOLUTION

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## IV. Mendelian Inheritance

THE factors of development, whether of an individual or of a species are both intrinsic and extrinsic, hereditary and environmental; but every evolutionary change must be inherited else it would be ever-changing and evanescent; consequently only inherited changes in organisms are of evolutionary value. The chief problems of evolution concern the manner of origin and fixation of these inherited changes. Nearly thirty years ago Osborn said: "When we have reached an inheritance theory that will explain the facts of heredity the problem of the causes of evolution will be a thing of the past."[1] We have now reached a theory of inheritance that explains the main facts of heredity and both directly and indirectly it has contributed enormously to the solution of the evolution problem. But although certain phases of that problem are now things of the past many new phases have appeared which are still unsolved.

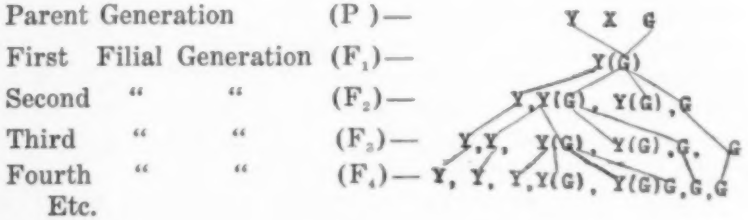
The history of Mendel's discovery and the principles of Mendelian inheritance have been described so frequently of late that it is not necessary to dwell upon them here. In bare outlines the essential features of this theory and of later additions to it may be summarized as follows:

### 1. Alternative Inheritance

Sexually produced organisms are mosaics of characters each of which is usually derived from one or the other of the two parents but not from both. These alternative characters or their germinal factors are known as allelomorphs. For example, Mendel found that when two varieties of peas are crossed, one having yellow seeds (Y) and the other green (G), all hybrids of the first generation ($F_1$), had yellow seeds but with green recessive or latent, Y(G), as was shown by the fact that when each of those hybrids was self-fertilized it produced

[1] Osborn, H. F., "Evolution and Heredity," Woods Hole Lectures, 1891.

a second generation ($F_2$) which formed yellow and green seeds in the proportion of three yellows to one green (3Y : 1G). In subsequent generations ($F_3$, $F_4$, etc.), if flowers were self-fertilized, green seeds always gave rise to plants with green seeds, one third of the yellow seeds produced plants which bore only yellow seeds, while two thirds of them produced plants which bore yellow and green seeds in the proportion of three to one (3Y : 1G) as in the second hybrid generation. The whole result may be summarized in the following scheme:




That is green-seeded plants always breed true when self-fertilized, those which are pure yellow-seeded also breed true, while those which are hybrid yellow and green with the green recessive, Y(G), give rise in each generation to yellow-seeded and green-seeded plants in the proportion of 1Y : 2Y(G) : 1G.

Mendel found that the same principle held true of several other contrasting characters or allelomorphs such as round (R) and wrinkled (W) seeds, tall (T) and dwarf (D) stems, etc. In every case he found that the first hybrid generation resembled one parent only with respect to any of these contrasting characters and these characters he called *dominant* while those which became latent or hidden in the hybrid he called *recessive*. In some cases hybrids are more or less intermediate between the parents and in such neither character completely dominates the other; thus Correns found that when

[2] All kinds of germ cells, whether plant or animal, male or female, are known as gametes and the union of male and female gametes gives rise to the zygote, which is the fertilized egg or the organism into which it develops. When two gametes with the same hereditary constitution unite they produce a *homozygote* or pure-bred individual; when gametes of different constitution unite they produce a *heterozygote* or hybrid. All the gametes produced by a homozygote are of the same hereditary type, those produced by a heterozygote are of two different types for each pair of contrasting characters of the parents. The various types of hereditary constitution, such as are indicated by YY, Y(G), GG in this table are known as *genotypes;* the types of developed organisms are *phenotypes.* Thus the three genotypes named constitute only two phenotypes since YY and Y(G) give rise to developed organisms which look alike.

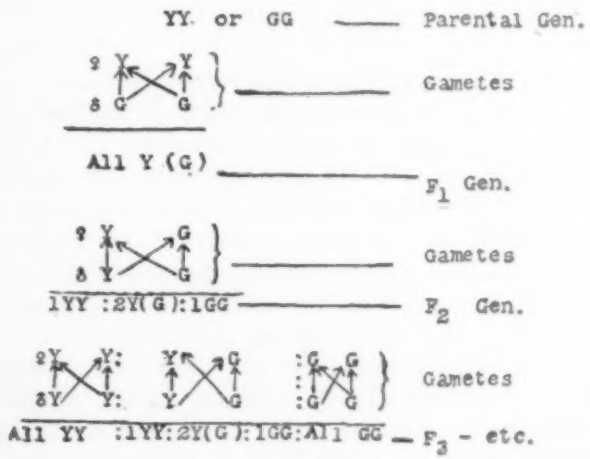
a white-flowered variety of *Mirabilis*, the "four o'clock," was crossed with a red-flowered variety all of the hybrids of the $F_1$ generation had pink flowers and from these in the $F_2$ generation there came white-flowered, pink-flowered and red-flowered forms in the proportion of 1 white; 2 pink; 1 red. This is a better illustration of the Mendelian law than is offered by the peas, since in this case the hybrids are always distinguishable from the pure dominants.

When peas with two contrasting characters are crossed only the dominant characters appear in the $F_1$ generation but in subsequent generations every possible combination of these characters occurs. Thus when peas with yellow and round seeds (YR) are crossed with green and wrinkled (GW) the $F_1$s are all yellow and round-seeded, but with green and wrinkled recessive, Y(G)R (W), and these, when self-fertilized, yield 9YR:3YW:3GR:1GW in the proportions named.

When peas with three contrasting characters are crossed, one having yellow and round seeds and tall stem, (YRT) with one having green and wrinkled seeds and dwarf stem (GWD) all hybrids of the first generation have yellow and round seeds and tall stem, the other characters being recessive, Y(G)R(W)T(D); but when these hybrids give rise to the second hybrid generation ($F_2$) all possible combinations of these original characters appear, and in the following proportions:—27RYT:9RYD:9RGD:9WYT:3RGD:3WYD:3WGT:1WGD. These characters are therefore separable in heredity; they behave as separate units in hereditary transmission and are therefore called "unit characters."

*Purity of Germ Cells.*—Mendel clearly perceived that there must be things in the germ cells which corresponded to or gave rise to these characters in the developed plant and, although he represented these things by letters, he did not attempt to define or describe them. It was evident that these things or factors or *genes* as they are now called were separable in heredity and that every germ cell, even though it came from a hybrid, could carry the genes for only one of each of these contrasting characters. Thus the hybrid produced by crossing green with yellow-seeded peas must form equal numbers of two kinds of germ cells, one carrying the gene for green seeds and the other that for yellow. No germ cell could carry both of these genes and this led to the most important of the Mendelian discoveries, namely that in the formation of germ cells there is a separation or segregation of genes so that every germ cell is "pure" with respect to the genes for any two contrasting characters.

Consequently when a germ cell carrying the gene for green (G) is fertilized by another carrying the same kind of gene (G) a pure bred green-seeded plant results (GG); when a germ cell carrying the gene for yellow (Y) is fertilized by another carrying a similar gene (Y) a pure yellow-seeded plant is produced (YY); but when a germ cell carrying the gene for yellow (Y) unites with one carrying the gene for green (G) a hybrid carrying both genes results, Y(G), the yellow gene however being dominant over the green. All the germ cells of a pure green-seeded plant carry the green factor, all those of a pure yellow-seeded plant carry the yellow factor, but half of the germ cells of a hybrid between yellow and green-seeded plants carry the factor for green and the other half the factor for yellow. Consequently since in the last named case these two kinds of germ cells are produced in equal numbers there is one chance in four that two germ cells with the yellow factor will unite or that two with the green factor will unite while there are two chances in four that a germ cell carrying the yellow factor will unite with one carrying the green factor. All this may be summarized in the following scheme:




*Monohybrids, Dihybrids, Trihybrids, etc.*—When parents differ in only a single pair of contrasting characters, as in yellow or green seeds, round or wrinkled seeds, tall or dwarf stem the resulting offspring are monohybrids; where they differ in two pairs of characters the offspring are dihybrids; where they differ in three pairs they are trihybrids, and where they differ in more than three pairs of characters the offspring are polyhybrids.

When the parents differ in only one pair of contrasting characters or allelomorphs, one of which completely dominates the other in the $F_1$ hybrids, there are in the $F_2$ generation 3 genotypes and 2 phenotypes, or developed types, in the relative number of 3 dominants to 1 recessive; this is the simple Mendelian or monohybrid ratio. When the parents differ in two, three or more such characters the number of types and their ratios are the square, cube, etc. of those for the monohybrid, as shown in the following table:

NUMBER OF GENOTYPES AND PHENOTYPES WHEN THERE ARE FROM 1 TO 7 PAIRS OF ALLELOMORPHS

| Pairs of Allelomorphs | Number of Genotypes in $F_2$ | Phenotypes in $F_2$ | |
|---|---|---|---|
| | | Number | Ratios |
| 1 | $(3)^1=3$ | $(2)^1=2$ | $(3:1)^1 = 3:1$, *i. e.*, 1 phenotype (of 3 individuals): 1 phenotype (of 1 individual) |
| 2 | $(3)^2=9$ | $(2)^2=4$ | $(3:1)^2 = 9:3:3:1$, *i. e.*, 1 phenotype (of 9 individuals): 2 phenotypes (of 3 each): 1 phenotype (of 1 ind.) |
| 3 | $(3)^3=27$ | $(2)^3=8$ | $(3:1)^3 = 27:9:9:9:3:3:3:1$, *i. e.*, 1 (27):3(9):3(3):1(1) |
| 4 | $(3)^4=81$ | $(2)^4=16$ | $(3:1)^4 = 81:27:27:27:27:9:9:9:9:9:3:3:3:3:1$, *i. e.*, 1(81):4(27):6(9):4(3):1(1) |
| 5 | $(3)^5=243$ | $(2)^5=32$ | $(3:1)^5 = 1(243):5(81):10(27):10(9):5(3):1(1)$ |
| 6 | $(3)^6=729$ | $(2)^6=64$ | $(3:1)^6 = 1(729):6(243):15(81):20(27):15(9):6(3):1(1)$ |
| 7 | $(3)^7=2187$ | $(2)^7=128$ | $(3:1)^7 = 1(2187):7(729):21(243):35(81):35(27):21(9):7(3):1(1)$ |

Where there are many allelomorphs the possible number of genotypes and phenotypes, due to different combinations, becomes very great and the relative numbers of the different phenotypes differ widely. In almost every case parents differ in more than a single character and in many cases, such as species crossings, they differ in a great many characters. It would not be possible to determine experimentally the absolute and relative numbers of different types in such cases without an enormous number of offspring. Fortunately it is usually possible to deal with each pair of contrasting characters by itself and without regard to the others so that, in such a case, one determines for each pair of characters whether they occur in the simple Mendelian ratio of 3:1.

Thus not only the different combinations which are possible but also the relative numbers or ratios of these different combinations are all explained by the simple principle of the "purity" of a germ cell with respect to any given gene and the chance union of germ cells in fertilization. *This is undoubtedly one of the greatest discoveries ever made in the field of biology and it is as far-reaching in results as it is simple in principle.*

This principle of the separableness of inheritance factors or genes in hereditary transmission has been demonstrated in hundreds of cases in both plants and animals and there is now no reason to doubt that it is a universal law of heredity. The many apparent exceptions to this law which were noted when the Mendelian discovery was new have been shown to be due to misunderstandings of the principles involved, or to unwarranted emphasis upon certain minor phases of Mendel's theory, or to a failure to properly analyze the characters in question or their causes.

*The Factorial Theory of Heredity.*—Germinal factors or genes are not wholly independent things though they may be localized in the chromosomes and may be separated, transposed and recombined in sexual reproduction. Furthermore it is not true that genes are merely the developed characters, in minute form, or that the factorial theory merely shifts the mysteries of heredity from the region of visible characters to that of invisible factors. Genes are not undeveloped characters but rather the elements whose combinations and interactions produce developed characters, just as combinations of chemical elements produce chemical compounds or as combinations of cells produce tissues and organs. The properties of the compounds or organs or characters are not to be found as such in the elements or cells or genes which enter into their genesis but they result from the combination or synthesis of these elements. Morgan says that each gene probably influences many characters and that it may possibly influence every character of the developed organism, and on the other hand it is known in certain instances that more than one gene is concerned in the production of a particular character. But while it is true that one gene may influence many characters and that more than one gene may be concerned in the production of a given character it is generally true that a particular gene is the *differential factor* in the production of any particular character. Very many factors are involved in the production of a white or red flower, of a white or black guinea pig, but in each case there is at least one factor which is *differential*, that is it is found in one of these alternatives and not in the other. This differential factor alone is emphasized in dealing with the hereditary causes of these differences,—it is sometimes spoken of as if it were the only factor or gene concerned in the production of the character, whereas all that is meant is that it is the differential factor.

*Multiple Factors.*—When more than one gene is concerned in the development of a character the factors or genes are said to be multiple. Thus in many instances the development of color is dependent upon two or more separable factors, and only when all of these factors are present does color develop typically. A similar condition is usually found in the inheritance of size, and gradations in size or color may be explained as the result of varying combinations of these multiple factors.

*Modifying Factors.*—Akin to cases of multiple factors are those conditions in which the action of a principal factor is modified by subordinate factors. Morgan and Bridges have discovered six or seven such factors which modify the "Eosin" eye color of *Drosophila.* These modifying factors are also separable in heredity and the stronger or weaker development of certain characters can be shown to depend upon certain combinations of these modifying factors. The fact that selection may serve to build up or to reduce a character is known to be due in some instances to the selection of individuals with or without certain of these modifying factors.

*Lethal Factors.*—Finally Morgan and his associates have demonstrated the existence of a considerable number of lethal factors in *Drosophila* which cause the early death of those gametes or zygotes in which such a factor is not balanced by a normal one. Consequently only heterozygotes with respect to such lethal factors survive and all individuals which are homozygous for a lethal factor usually die so early that they are never seen. Nevertheless their existence can be determined by indirect methods, such as linkage with sex. Such lethal factors modify expected Mendelian ratios and greatly complicate the study of genetics, but they do not destroy its fundamental principles, indeed when properly understood they furnish one of the strongest proofs of the truth of the factorial theory of heredity.

The factorial theory is as necessary to the study of heredity as is the atomic theory to the study of chemistry and the one is as well justified by the results obtained as is the other. Weismann says that for a long time he tried to avoid the assumption of the existence of inheritance factors, but he finally came to the conclusion that no understanding of the phenomena of heredity was possible on any other basis. At present inheritance factors are no more hypothetical than are atoms and electrons. We know not only that they exist but also that they are located in the chromosomes; we know how they are separated and recombined in sexual reproduction and we know that

evolution is caused in some cases at least by changes in these factors or genes.

## 2. Blending Inheritance

When the Mendelian theory was new it was generally supposed that there were forms of inheritance which differed materially from the Mendelian type; in fact it was supposed that the latter was one of the less common forms of heredity and that blending of parental traits and not separation was the rule. Among such cases of blending inheritance may be mentioned the color of hybrids of white-flowered and red-flowered "four o'clocks" and of white and black men, the size of hybrids of large and small races of rabbits or other organisms, etc. In these cases the $F_1$ generation is more or less intermediate between the two parents but the significant fact, which was formerly overlooked, is that in the $F_2$ and subsequent generations we have a more or less complete segregation of the original characters out of these hybrids in which the characters are blended. In the $F_2$ generation the pink-flowered "four o'clocks" produce white-flowered and red-flowered as well as pink-flowered plants, the children of mulattoes range in color from white to black, the offspring of those hybrids which are intermediate in size between their parents are large and small and intermediate. In these cases there is a true Mendelian segregation of genes but owing to the fact that one gene does not completely dominate its allelomorph or to the fact that multiple factors are present in varying numbers the hybrid is intermediate between the two parents.

Other cases of apparent blending inheritance are found in quantitative characters in which the size of offspring or the degree or extent of their pigmentation ranges all the way from one parental type to the other. Such cases have been studied particularly by Castle in rabbits and in hooded rats and he concluded that such intergrades could not be explained by the segregation of constant genes but must be attributed to quantitative and qualitative changes in the genes themselves. MacDowell, on the other hand, showed that in rabbits the intergrades in size may be explained more satisfactorily by the multiple-factor hypothesis than by Castle's hypothesis of changes in the genes themselves. And the work of Morgan and his associates on the gradation of eye-color in *Drosophila* has shown that such gradations are due to "modifying factors" which increase or diminish the action of the principal factor.

Castle has more recently accepted this principle of modifying factors as an explanation of the results of his work. There are then in all these cases several factors which are concerned in the production of these quantitative characters and the intergradations which occur are due to varying combinations of these factors rather than to modifications of the factors themselves. Blending inheritance, therefore, so far from being a contradiction of the Mendelian principle of the segregation of unchanging factors, becomes an important argument in favor of that principle.

### 3. Species Hybrids

*a. Numerous Allelomorphs.*—In species crosses certain phenomena occur which do not appear to be Mendelian in character. For example, species hybrids are usually intermediate between the two parents so that it looks as if this were a case of blending inheritance. This appearance may be due to the large number of dominant factors which are contributed by each parent so that in general the offspring seem to be intermediate; or it may be due to the fact that neither allelomorph of a pair completely dominates the other in which case there should be a segregation of parental characters in the $F_2$ generation. In the classical cases of Mendelism the varieties crossed differ in only a few characters. Linnean species, however, differ in very many characters and if the dominant characters are pretty equally distributed between the two species the result would be that the hybrids would appear to be intermediate. This is in fact one of the most general features of hybrids between species. If such intermediacy is really the result of the combination of large numbers of contrasting characters, or rather of their genes, the $F_2$ generation should present a large number of segregations and therefore wide variability. Owing to the large number of contrasting characters or allelomorphs in different species the number of possible combinations in the $F_2$ generation is very great (p. 174) and immense numbers of offspring are necessary in order to determine whether or not all these possibilities are realized and still larger numbers are needed to determine the *relative* numbers of these different types.

Thus the *smallest* number of offspring which would represent the Mendelian ratios of different types, where one allelomorph completely dominates the other, would be for

| | | | | | |
|---|---|---|---|---|---|
| 1 | pair | of | Allelomorphs, | 4 | $F_2$ individuals. |
| 2 | " | " | " | 16 | " " |
| 3 | " | " | " | 64 | " " |
| 4 | " | " | " | 256 | " " |
| 5 | " | " | " | 1,024 | " " |
| 6 | " | " | " | 4,096 | " " |
| | Etc. | | | | |

Of course a much greater number than that must actually be observed if the ratios are to be determined with any approach to accuracy. For example, in determining the simple 3 : 1 ratio in the cross of yellow-seeded and green-seeded peas, Mendel observed 6,022 yellow seeds and 2,001 green seeds and 15 different investigators who have made this cross have recorded in the $F_2$ generation a total of 152,824 yellow-seeded to 50,676 green-seeded peas which makes the ratio 3.004 : .0996 or very nearly 3 : 1. (See Morgan, 1919, p. 24.) It would therefore be an enormous labor to determine with any accuracy the relative numbers of different types which would result where there were even five or six pairs of allelomorphs.

For example, Baur has determined the existence of more than 20 different factors for the color and form of flowers in the snap-dragon *Antirrhinum*. Lotsy crossed two species of snap-dragon, *A. majus* × *A. molle;* the $F_1$ hybrids were intermediate in all respects and were completely fertile; out of an $F_2$ population of 255 plants, he distinguished about 25 different flower types, besides many other character differences such as size, form of leaf, habit of growth, etc. One of these $F_2$ plants produced 209 plants of the $F_3$ generation all of which had different types of flowers, but wherever single pairs of allelomorphs could be recognized and followed it was found that their segregation in the $F_2$ and subsequent hybrid generations approximated the Mendelian ratio of 3 : 1.

Detlefsen obtained essentially similar results in crossing two different species of the guinea pig, *Cavia porcellus* × *C. rufescens*. He studied in particular five pairs of contrasting characters in the color and arrangement of the hair and as a result of this work he concludes that in the hybrids of these species inheritance is Mendelian.

*b. Infertility.*—But another and even greater difficulty in determining whether species-crosses are Mendelian or not results from the fact that such hybrids are frequently but not invariably more or less infertile. If certain combinations of allelomorphs should be sterile or less fertile than others it

would cause wide departures from the expected ratios and in cases where infertility of hybrids is the rule, it is of course impossible to determine whether or not Mendelian segregation occurs. There are however many cases in which such hybrids are fertile and in all such cases there are evidences that inheritance is Mendelian. On the whole there is no good reason to suspect that species-crosses differ fundamentally from variety-crosses in this respect.

### 4. Unequal Reciprocal Hybrids

In typical Mendelian inheritance reciprocal crosses yield identical results. Thus it does not matter in a cross between white and red guinea pigs whether the male is white and the female red or *vice versa;* the results are the same in either case. But in some instances reciprocal crosses yield different results. Thus the cross between the male ass and the female horse yields a mule, but the reciprocal cross between the female ass and the male horse produces a hinney. When the hybrid resembles the father more than the mother it is said to be "patroclinous"; when the reverse is true it is "matroclinous." Such unequal reciprocal hybrids have been studied especially in the Œnotheras by de Vries and he comes to the conclusion that they are due to the fact that the male and female gametes of a species may carry different factors—that they may be heterogamous as contrasted with the more usual conditions where they are isogamous. The cause of heterogamy is obscure, but de Vries suggests that the pollen which receives maternal factors, for example, may remain rudimentary so that all the active pollen carries only paternal factors while the reverse may be true of the egg cells.

The extensive work which Morgan and his associates have done on lethal factors in *Drosophila* shows that they play an extremely important part in the non-survival of certain gametes or zygotes. They have demonstrated that a number of such lethal factors are located in the X chromosome and that all individuals in which such a factor is not balanced by a normal allelomorph die early. All males that receive such a factor die since there is only one X chromosome in the male; all females that receive it in both X chromosomes die, while only those survive that have such a lethal factor in one or neither of the X chromosomes.[3]

[3] Bridges has shown also that patroclinous sons and matroclinous daughters may result from a phenomenon which he calls "non-disjunction," that is the failure of certain pairs of chromosomes to separate during the maturation of the germ cells.

In some such manner as this it may be possible to explain the condition of heterogamy and unequal reciprocal hybrids. Such hybrids therefore do not disprove the Mendelian law but they furnish additional and unexpected support for it when they are properly analyzed. We may therefore conclude that the Mendelian law of heredity, especially as regards the segregation of inheritance factors, is of universal occurrence—that there is no other type of inheritance.

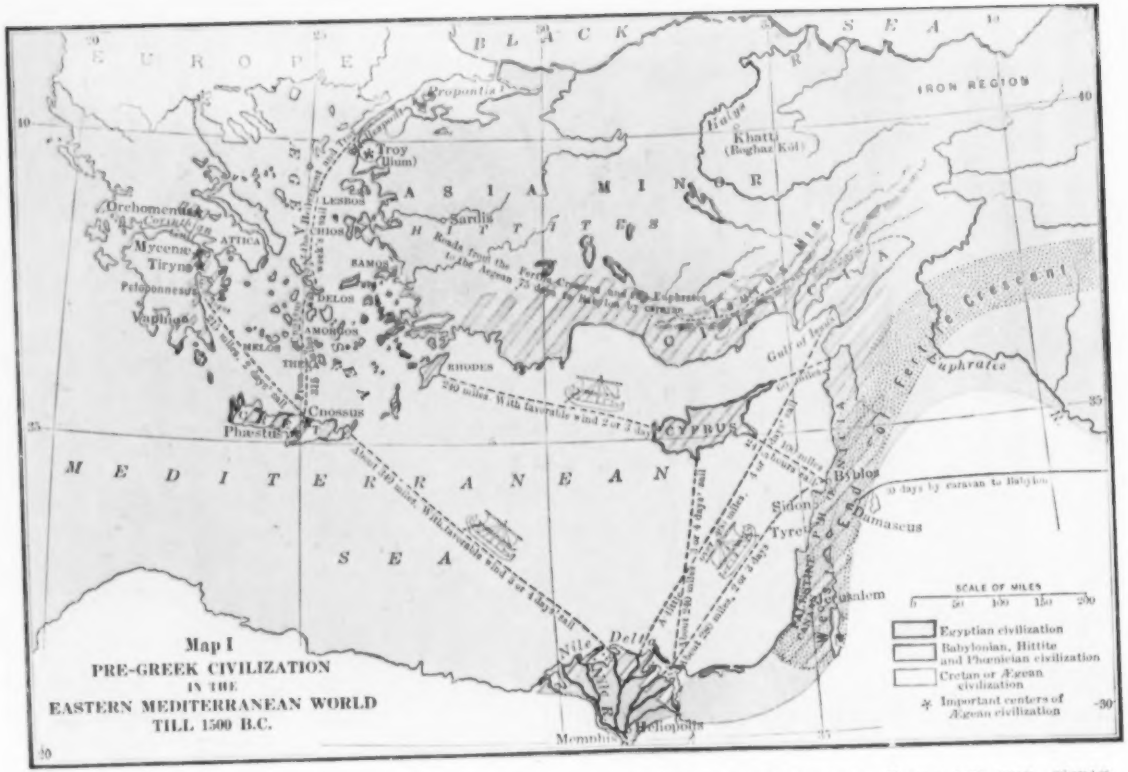



FIG. 85. MAP OF THE EASTERN MEDITERRANEAN, SHOWING ESPECIALLY THE RELATIONS OF EGYPT AND THE ÆGEAN. (From the author's "Ancient Times," by permission of Ginn & Co.)

# THE ORIGINS OF CIVILIZATION[1]

By Professor JAMES HENRY BREASTED
THE UNIVERSITY OF CHICAGO

## LECTURE TWO

### THE EARLIEST CIVILIZATION AND ITS TRANSITION TO EUROPE, II

Just as the Central American culture, particularly in Yucatan, was in close contact with Cuba in pre-Columbian times, so the shipping of the Pharaohs in the Pyramid Age maintained frequent intercourse with Crete. The map (Fig. 85) shows us how Crete, the southeastern island outpost of Europe, is thrust far out into the Mediterranean toward Egypt, almost opposite the mouths of the Nile. This intercourse was facilitated by favoring winds and currents making the three hundred and forty mile interval a matter of a few days' sail. Thus the products of the Nile craftsmen began to find their way into Crete after 3000 B.C.

It can be no accident that the appearance of metal in Crete and on the neighboring mainland of Asia coincides in date with the appearance of the first sea-going ships built by the Pharaohs. The peculiar copper dagger of Egypt, ornamented with lines diverging from a central rib, passed across Europe and


FIG. 86. COPPER DAGGERS OF EGYPT AND EARLY EUROPE, SHOWING THE TRANSITION OF METAL FROM THE NILE VALLEY TO EUROPE. (From the author's "Ancient Times," by permission of Ginn & Co.)

[1] Delivered before the National Academy of Sciences in Washington, D. C., April 28 and 29, 1910, as the seventh series of lectures on the William Ellery Hale Foundation.

FIG. 87. EGYPTIAN GLAZED BEADS FOUND IN AN EARLY BRONZE AGE BURIAL IN ENGLAND. (After Sayce in *Journal of Egyptian Archæology*, Vol. I.)

FIG. 88. STONE VASES OF EGYPT (LEFT) AND OF CRETE (RIGHT) IN THE PYRAMID AGE, SHOWING HOW THE EARLY CRETANS REPRODUCED EGYPTIAN FORMS. (From the author's "Ancient Times," by permission of Ginn & Co.)

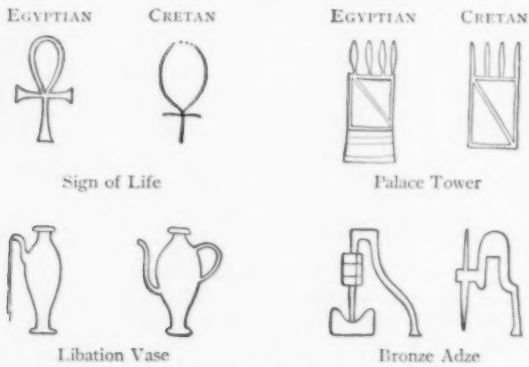



FIG. 89. EGYPTIAN HIEROGLYPHICS COMPARED WITH SIGNS FROM EARLY CRETAN WRITING. (After Sir Arthur Evans.) The signs are arranged in pairs with the Egyptian sign on the left and the corresponding Cretan sign on the right.

penetrated as far north as the Scandinavian countries (Fig. 86), and Egyptian glazed beads have been found as far westward as the Neolithic or Early Bronze Age graves of the British Isles (Fig. 87). The beautiful stone vases wrought by the skilled craftsmen of the Pyramid Age with their new tubular drill (Figs. 73–74), roused the emulation of the gifted Cretans, and they presently succeeded in making very clever copies (Fig. 88). As a result of such endeavors thriving industrial communities, exhibiting surprising native capabilities and artistic gifts, arose in Crete, and their copying, quite freed from any slavish imitation, began to display a vigorous and creative individuality which brought forth the earliest civilization on the southeastern fringes of Europe.

This new Cretan civilization, revealed to us especially by the brilliant discoveries of Sir Arthur Evans at Cnossus, and also by very creditable American excavations, continued to develop after 2000 B.C. in close contact with the Oriental life on the Nile. As the Cretans developed their own writing, the connection with Egyptian hieroglyphic is evident, as Sir Arthur Evans has showed (Fig. 89). After the expansion of Egyptian power into Asia and the Mediterranean in the Feudal Age (or Middle Kingdom, flourishing for two centuries after 2000 B.C.)

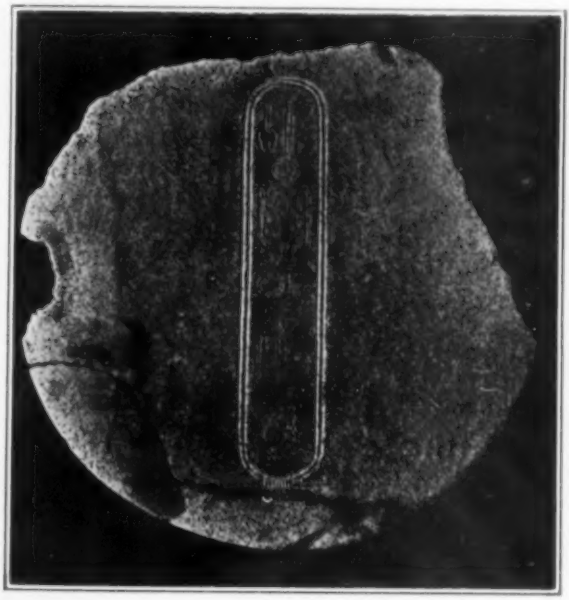


FIG. 90. ALABASTER VASE LID BEARING THE NAME OF THE EGYPTIAN PHARAOH KHIAN FOUND BY SIR ARTHUR EVANS UNDER A WALL OF THE CRETAN PALACE OF CNOSSUS—PROBABLY ABOUT THE 17TH CENTURY B.C.

FIG. 91. A LINE OF CRETAN ENVOYS (THE LOWER ROW) IN EGYPT BRINGING TRIBUTE TO THE PHARAOH IN THE 15TH CENTURY B.C. The scene is taken from a painting on the wall of the tomb of Rekhmire, Grand Vizier of the Pharaoh Thutmose III., the greatest of the Egyptian conquerors.

and the Empire (1580–1150 B.C.), the development of the first great navy enabled Egypt to maintain unchallenged supremacy in the eastern Mediterranean and among the islands of southeastern Europe. The beginnings of this Mediterranean power of Egypt are suggested by the name of the Pharaoh Khian, engraved on an alabaster vase lid found under a palace wall at Cnossus (Fig. 90).

As the Egyptian Empire established its power in the northern Mediterranean, the Pharaoh appointed a governor over the Ægean Islands. Cretan envoys bringing their tribute to the court of the Pharaoh were a common sight in the fifteenth century B.C. (Fig. 91). Such Cretans who had visited the Nile,

FIG. 92. A CRETAN VASE DECORATED IN RAISED PATTERNS WITH EGYPTIAN FLOWERS. A fine example of the remarkable decorative art of Crete in the Grand Age about the middle of the 15th Century B.C.

and likewise Egyptian wares common in the Cretan markets, brought many a Nilotic motive into the art and life of this remarkable island people which they promptly appropriated. Thus Egyptian flowers like the lotus or the papyrus became common in Cretan art, where they were employed with new life, freedom and vigor, which are a marvellous expression of Cretan ability in decorative art (Fig. 92). This magnificent decorative art of Crete also had its influence on Egypt in return, for the situation was one in which reciprocal influences were inevitable. It is sometimes a question among archeologists as to which was the giver and which the receiver (Fig. 93).

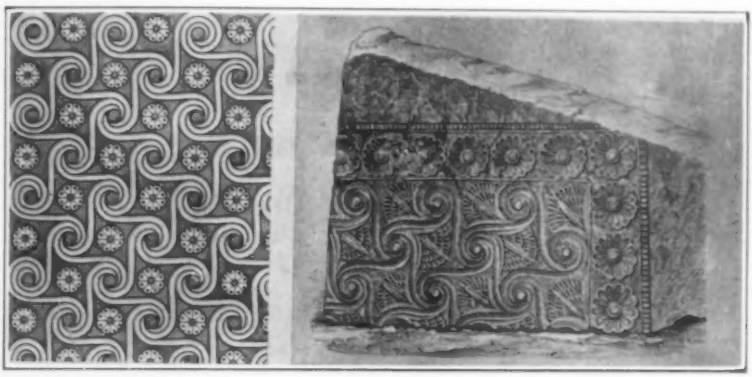


FIG. 93. CEILING DECORATIONS OF EGYPT AND MYCENÆAN EUROPE. The Egyptian pattern (on the left) is from a painted ceiling in an Egyptian tomb at Thebes (Egypt), while the Mycenæan design was carved on a tomb ceiling at Orchomenos in Greece, and belongs to the outgoing Ægean art of the period when the Greeks were already taking possession of the Ægean world—the period which was called Mycenæan after Schliemann's discoveries at Mycenæ.

While the highly developed arts and crafts of Egypt furnished the Ægean world with the devices and the technical processes for carrying on a flourishing industrial life, the architecture of the Nile did not leave a noticeable mark on the fringes of Europe until the Greek Age which we are now approaching. The limited power and resources of the Cretan state or states would not have permitted any Cretan ruler to vie with the vast monumental architecture of the Nile. The gigantic clerestory hall of the Karnak temple (Fig. 94) was a structure possible only to a ruler of imperial wealth and resources, commanding a highly efficient body of architectural engineers such as existed at this time nowhere outside of Egypt. It is impossible in this brief presentation to do more than suggest in terms of such architecture as this, the imperial development which went on in Egypt after the sixteenth cen-

FIG. 94. COLUMNS OF THE GREAT KARNAK CLERESTORY HALL. A hundred men can stand on the capital of each column of the nave.

tury B.C. (Figs. 95–96). The resources and impulses which had prompted this great expansion of Egyptian life and power were exhausted by 1200 B.C. and fifty years later Egypt was nationally prostrate and powerless.

A similar development of human life had meantime been

going on in Western Asia, and if we have been late in reaching it, this has been chiefly due to the fact that the Babylonian world of the lower Tigris and Euphrates lay separated from the Mediterranean by a great northern extension of the Arabian desert over five hundred miles across. Babylonian civilization, thus cut off from immediate contact with the Mediterranean world and Europe, was later in affecting the tide of Oriental influences which for ages pressed upon the life of Europe and the West, and in Hebrew and Christian religion has not yet ceased to do so. Another reason which has delayed us in taking up Western Asia is found in the fact that the *prehistoric* development of the region, as we have already stated, has yet to be investigated, and as a whole to be recovered from the still inaccessible and undiscovered sources. But Babylonian influence was not less great and important because it was somewhat later than that of the Nile.

A glance at the map shows us that southern Babylonia and northern Egypt are practically in the same latitude. Yet their respective situations are totally different. Egypt, strategically considered, is surprisingly protected from invasions and assaults of foreign peoples. Its isolated situation due to the wastes of the great Sahara on each side and the Mediterranean on the north, enabled it to enjoy a continuous development uninterrupted by foreign intrusion for many centuries at a time. In an age when maritime peoples were still unknown on the Mediterranean, this body of water was a protecting barrier against the Stone Age barbarians of the north, of enormous importance to Egypt, and to this freedom from invasion at the hands of the backward northern peoples, we

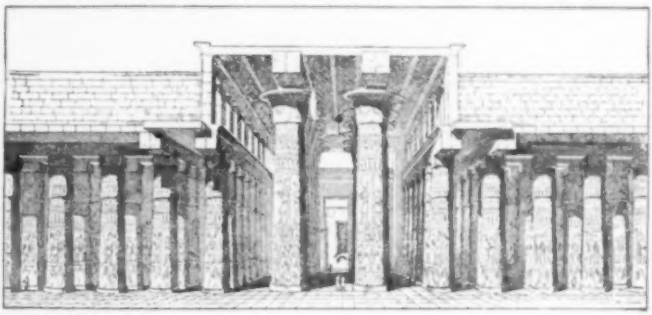


FIG. 95. RESTORATION OF THE GREAT KARNAK CLERESTORY HALL. Built chiefly by Ramses II. in the 13th century B.C., some 1,500 years after the incipient clerestory of Khafre at Gizeh (Fig. 79), it represents the culmination of a long development which has brought forth tall and stately clerestory windows in place of primitive light-chutes, and imposing colonnades in place of rectangular piers (Fig. 80). From such Egyptian temple halls the basilica structures of Hellenistic and Christian Europe have descended.

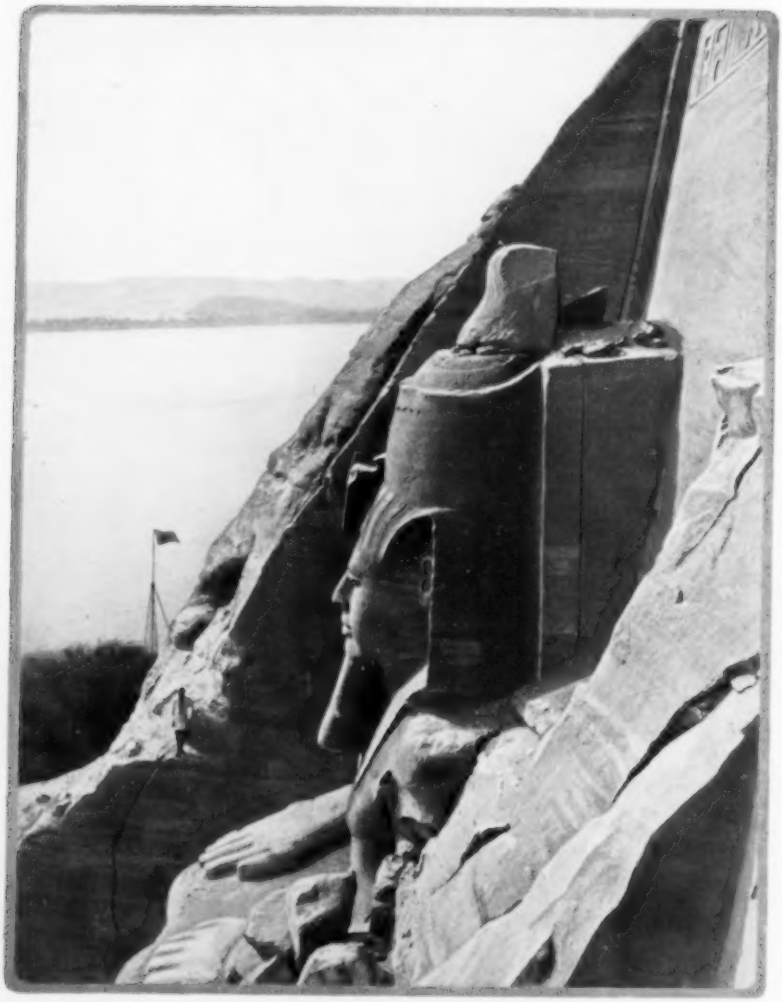


FIG. 96. ONE OF THE COLOSSAL PORTRAIT STATUES OF RAMSES II. ADORNING THE FRONT OF THE CLIFF TEMPLE OF ABU SIMBEL ON THE NILE IN NUBIA. There are four such figures along the front of the temple; each is seventy-five feet high.

may attribute in no small degree Egypt's advance to civilization at a time when no such great civilized nation had appeared anywhere else.

The alluvial plain on the lower Tigris and Euphrates, which we call Babylonia, was, on the other hand, continually exposed to invasion by the less developed peoples of the mountains on the north and east. At the same time the nomad population, which still finds pasturage for its flocks along the northern fringes of the Arabian desert, beset Babylonia with a similar

unceasing menace from the other side. The history of western Asia is often made up of the struggle between the mountaineers on the north and the desert nomads on the south, for the possession of the Fertile Crescent which lay between, and of which Babylonia forms the eastern and Palestine the western end. It was therefore impossible for any people occupying the Babylonian Plain to develop without interference in accordance with its own capabilities and native gifts. The civilized development here was repeatedly halted and sometimes stagnated, as it has done in modern times, for centuries. This was not seldom due to the further fact that the *invasions* were often at the same time *migrations* bringing in a relatively large body of foreign population.

Retarded from prehistoric times by the rigor of the northern winters and the cold of the outgoing glacial age, western Asia was far behind Egypt at the opening of the fourth millennium

FIG. 97. EGYPTIAN RELIEF (LEFT) OF THE 30TH CENTURY B.C., SHOWING THE STANDING FIGURE OF AN EGYPTIAN NOBLE, AND EARLY SUMERIAN RELIEF (RIGHT), SHOWING THE FIGURE OF A SUMERIAN CITY KING OF THE SAME AGE. We have here an opportunity to compare the art of the two cultures at the same age. It may be noted that the Babylonian relief is a royal monument while that of Egypt is from the tomb of a noble only.

FIG. 98. THE CENTRAL PORTION OF THE MOUND OF THE OLD SUMERIAN CITY OF NIPPUR, NOW CALLED NIFFER, IN CENTRAL BABYLONIA. The highest portion of such mounds covers the public buildings and especially the temple mount or tower. (By courtesy of the University Museum, Philadelphia.)

B.C., and the prehistoric advance of Babylonia was for the reasons mentioned above so slow that in the thirtieth century B.C. her culture was still noticeably inferior to that of Egypt (Fig. 97).

The earliest towns on the Babylonian alluvium were rarely more than a few hundred paces across. They were built of sun-dried brick and as a result of the action of weather and successive destructions at the hands of hostile invaders, a considerable volume of disintegrated brick accumulated as the centuries passed. This rubbish was not cleared away when the new buildings were put up, and hence the town finally stood on a high mound (Fig. 98). Such a mound is called by the Arabs a "tell," a word which therefore appears very commonly in the geographical names of Egypt and western Asia. Traversing the Babylonian plain to-day the modern traveler is rarely out of sight of such a mound somewhere on the horizon. These are the treasuries whence the evidence for the reconstruction of early Babylonian life and history is chiefly drawn. Thus far only a small proportion of the early Babylonian mounds has been excavated and thoroughly investigated. Indeed the rigorous methods of Mediterranean archeology have only recently

and in limited measure, begun to be applied to Babylonian research.

Each one of these mounds represents an early city-kingdom consisting of the town and a fringe of outlying fields. You could have walked across the whole kingdom in an hour or two. At the head of this petty realm was a king, whose monuments, excavated from the mound now covering his town, sometimes reveal him to us in primitive sculpture engaged in the ceremonious functions of his little state (Fig. 99).

The people over whom he ruled are called Sumerians in the documents of the time. While their racial origin is still uncertain, it is evident that they were not Semites, like the nomads of the neighboring desert, and their affinities are therefore to be sought in the mountains. Well back in the fourth millennium B.C. they had developed their own writing. Like the writing

FIG. 99. AN EARLY SUMERIAN CITY KING OF THE 30TH CENTURY B.C. ENGAGED IN PUBLIC CEREMONIES. The relief is engraved on the limestone base of some ceremonial object, presumably a mace, the handle of which was thrust into the hole in the middle of the block. In the upper relief the king is seen standing at the left with a basket probably filled with earth on his head. Before him in a line his children approach, and behind him is his cup-bearer. The ceremony is probably that of beginning the digging for some important public work like a canal or the foundation of a temple. Below the king is seated at the right with much the same personages about him. The birdlike features and crude drawing evince the primitive and undeveloped character of the art. The inscriptions in cuneiform record the names of the individuals shown. That of the king was Urnina, a ruler of Lagash.

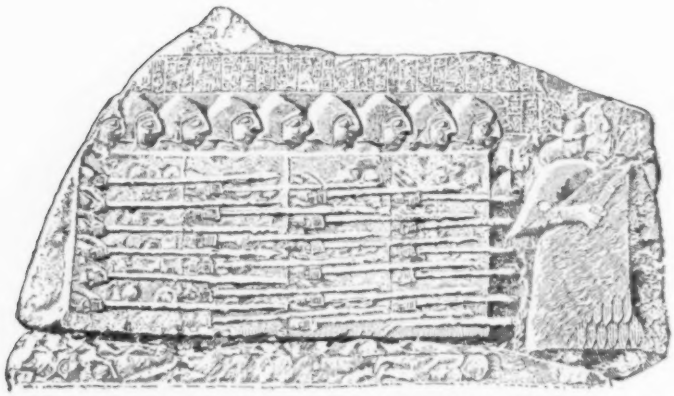


FIG. 100. A SUMERIAN PHALANX. This relief of the 29th century B.C. is a fragment of a round-topped stela commonly called the Vulture Stela, recording the victories of Eannatum, king of Lagash. The scene shows him at the head of a phalanx of the troops of his little city-kingdom.

of Egypt it grew up out of picture signs. As a result of the process of writing on soft clay tablets, the individual lines of the pictures assumed the forms of wedges, and for this reason the writing of these people has been called *cuneiform* (Latin *cuneus*, "wedge"). It never developed alphabetic signs. The Egypto-Babylonian culture group thus devised two physical processes of writing: the one by tracing the characters with a pen and a dark pigment on a vegetable membrane; the other by impressing or incising the characters on a soft or plastic substance. The latter process, that of Asia, survived for a time in

FIG. 101. EARLY SUMERIAN CYLINDER SEAL IMPRESSION SHOWING THE FIGURES OF ANIMALS IN BALANCED OR ANTITHETIC ARRANGEMENT. It must be remembered that these tiny figures were cut by the lapidary around a cylinder of hard stone not thicker than one's finger, and sometimes much smaller, and perhaps only half as long. They represent a great and noble art in striking contrast with the feebleness of the sculptor in relief (Fig. 99).

the clay tablets of Crete and the waxen tablets of the Roman gentleman, and then perished; the other, the method of Egypt, still survives in the pen, ink and paper of modern usage.

These Sumerian city-kingdoms had already gained agriculture and were practising it in the fourth millennium B.C. Their oldest documents mention emmer, wheat and barley as everyday matters. The occurrence of wild wheat, or emmer, which was the ancestor of domesticated wheat, growing in a wild

FIG. 102. AN EAGLE SURMOUNTING TWO ANTITHETICALLY PLACED LIONS FORMING THE ARMS OF THE CITY OF LAGASH. Engraved on a silver vase of king Entemena of Lagash in the 29th century B.C. It forms a fine example of early Babylonian heraldic art.

state in western Asia as far east as the Kermanshah Pass, may yet lead to the conclusion that it was domesticated in Babylonia, but we must make the botanical exploration of the Near East more nearly complete before this question can be finally settled. That wheat and barley were domesticated by the Egypto-Babylonian group and passed thence into Europe is, however, perfectly clear.

Cattle and sheep were likewise possessed by these people long before 3000 B.C. Further investigation of the culture levels of the fourth millennium, still almost untouched, will be necessary before we can reach final conclusions regarding the sources of these animals. It is interesting to observe that the Sumerians already possessed the wheel as a burden-bearing device, so that they were able to build wheeled carts. It is pos-

FIG. 103. THE ARMS OF LAGASH AS SHOWN IN FIG. 102, FROM A PLAQUE OF BITUMINOUS CLAY.

sible that they already employed the ass to draw such carts. In any case they possessed the animal in a domesticated state, a fact which points toward connection with Egypt. At the same time they came into possession of copper. The earliest dated pieces of copper in Asia are a thousand years later than the copper needles of the earliest graves in Egypt, and it is evident where we must look for the original home of metallurgy.

These early Sumerian city states were constantly embroiled in petty wars among themselves. The art of warfare among them had reached an extraordinarily high development, far superior to that of Egypt. It is a justifiable generalization to say that the arts of peace were developed chiefly in Egypt, while those of war were due to the peoples of western Asia, especially the Sumerians and Assyrians. We find the Sumerians already employing the phalanx as early as the twenty-ninth century B.C. (Fig. 100). The Egyptian monuments show that this formation had reached the Mediterranean by the twelfth century B.C., and there can be no doubt that the later Greek phalanx was inherited from the ancient Sumerians. It may be a fair question whether the existence of this formation among the Sumerians at such an early date does not point to a western origin for them somewhere in Asia Minor, whence their military experience was easily communicated to Europe.

While early Sumerian art as exhibited in sculpture was at first crude and backward (Fig. 99), the Sumerians developed a decorative art of epoch-making importance. It was practised with the greatest success by the lapidaries, who were called upon to produce the stone cylinder seals employed by the Sumerians to seal their clay documents. The content of this decorative art was chiefly animal and human figures arrayed in a balanced or antithetic arrangement (Fig. 101), which we have already seen in the prehistoric art of Egypt (Fig. 63). As employed by the Sumerians these groups were given startling vigor and power by depicting the figures in violent motion or engaged in tremendous muscular effort. Thus arose the heraldic art familiar to us all in the "lion and the unicorn." The Sumerians therefore contributed to the decorative art of the world a rich treasury of powerful forms to which it has ever since been indebted.

FIG. 104. BALANCED ANIMALS, EGYPTIAN, SUMERIAN AND ÆGEAN. Antithetically placed animal figures were common in the art of Egypt from the remotest times, probably earlier than in Babylonia, as noted in Fig. 63. They are a conclusive evidence of the culture diffusion within the Egypto-Babylonian group, whence such influences passed to the Ægean as shown in the last figure of the three.

Among such figures is that of an eagle with its wings and talons extended in antithetic arrangement. With its talons the bird at the same time clutches the backs of two lions, likewise antithetically placed (Figs. 102 and 103). The lions sometimes turn their heads and set their teeth savagely into the outspread pinions of the eagle. This device formed the emblem of the Sumerian city of Lagash, that is, what we should now call the arms or armorial bearings of the little kingdom. The eagle with outspread wings early passed into Asia Minor (or is this another evidence of the origin of the Sumerians in Asia Minor?), and thence into the Ægean (Fig. 104) and Europe, where we are familiar with it in the arms of the southeast European states, like Austria. It eventually reached the German states, like Bavaria and Prussia, and later also Russia and France. It was from these European sources that we drew our own American eagle, for the earliest ancestry of which we must therefore go back to an ancient Sumerian city-state.

Lack of stone in Babylonia prevented the development of such massive monumental architecture as we have found on the Nile. The Sumerian builder was dependent exclusively upon brick, chiefly sun-dried, but occasionally baked to protect the faces of his larger structures from the destructive action of rain. His buildings were almost all small and unpretentious. He never undertook a treatment of the void, such as developed the piers and colonnades of Egypt. Western Asia was therefore entirely without the column until Greek times, notwithstanding the elaborate colonnades with which Ferguson and other historians of architecture have embellished their restorations of western Asiatic buildings. The Sumerian architect's

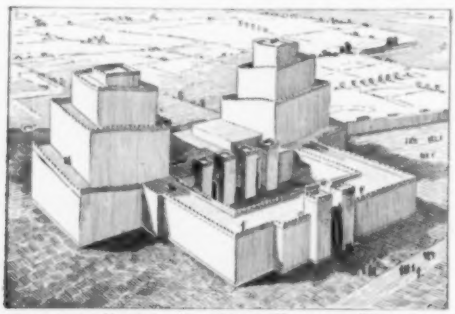


FIG. 105. A PAIR OF EARLY ASSYRIAN TEMPLE TOWERS, ILLUSTRATING THE TEMPLE TOWER OF THE SUMERIANS. (After Andræ.) Such towers were not commonly erected in pairs. These two belonged to the double temple of Anu and Adad in the city of Assur, and as restored by the excavators they serve very well to illustrate the earlier Sumerian temple towers. It was such a structure which gave rise to the tradition of the tower of Babel. From it have descended the prevailing types of tower and spire architecture in Europe (see Fig. 126).

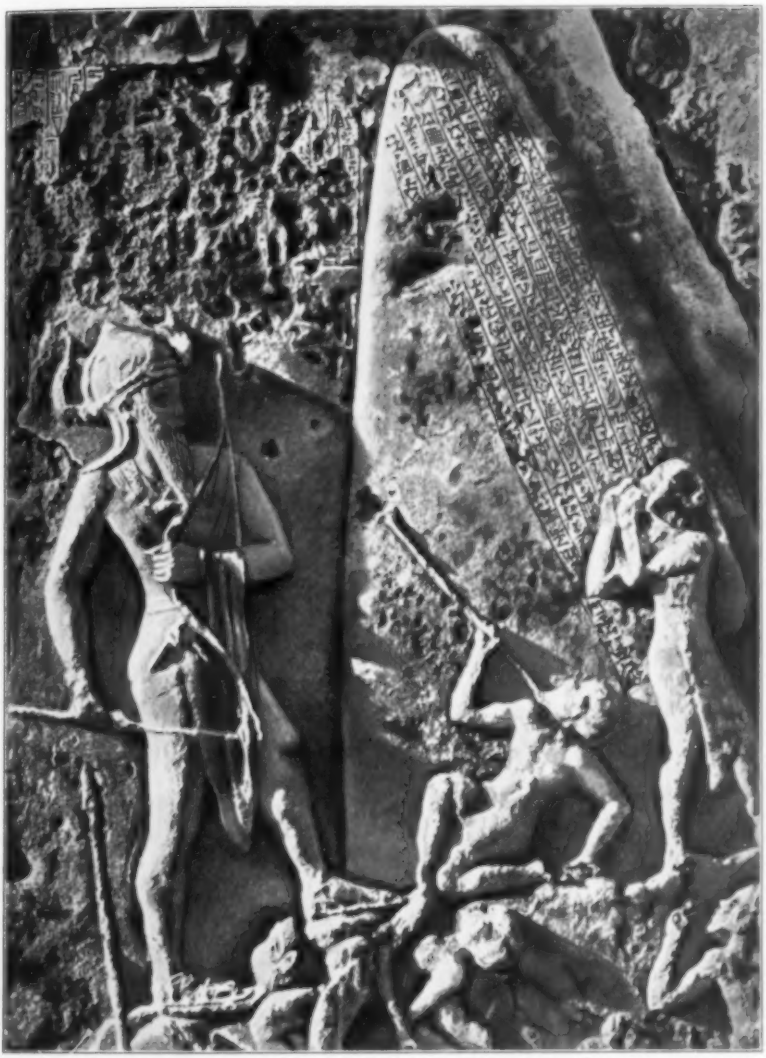


FIG. 106. MONUMENT OF VICTORY OF THE SEMITIC KING NARAMSIN OF AKKAD: THE EARLIEST GREAT SEMITIC WORK OF ART (28th century B.C.). The king, whose figure is depicted in heroic proportions, has pursued the enemy to the summit of a mountain. The artist has selected the dramatic moment when the foe has surrendered and the king indicates his merciful intentions by lowering the point of his weapon.

device for carrying the wall or the roof over the void was the arch and the vault, and he never made wider interiors than he was able to span with his vault. It was from the buildings of western Asia, as we shall see, that the arch was transmitted to Europe.

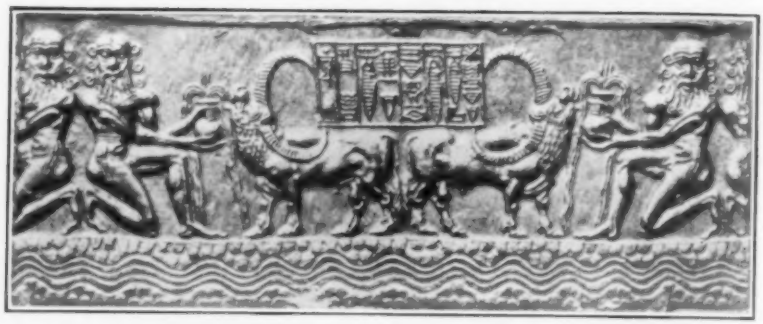


FIG. 107. IMPRESSION FROM A BABYLONIAN CYLINDER SEAL OF AKKADIAN AGE IN THE OLD SUMERIAN MANNER. (Collection de Clercq.)

While the Sumerian made no contribution to the treatment of the *void*, he was the more successful in his handling of the *mass*. He broke up the monotonous surfaces of his brick walls by a rhythmic distribution of alternate panels and pilasters. As to the form of the mass he made a real contribution in the artificial temple mount erected alongside the sanctuary in the form of a rectangular tower with an ascending ramp winding about it from base to summit by which the priest climbed to the top (Fig. 105). This structure, which gave rise to the legend of the Tower of Babel, marked the entrance of the tower into architecture. From it have descended the leading tower forms of the West, as we shall see.

It will be seen that Sumerian civilization made fundamental contributions to the life of man, to which we are still indebted. The exposed situation of their home, however, as we have already stated, made it impossible for them to continue an uninterrupted development. The Semitic nomads who drifted down the Two Rivers, were strong enough to set up a small kingdom in the district of Akkad, the northern portion of the Babylonian Plain. We can trace the career of the Sumerian city-kingdoms from their earliest emergence in the thirty-first century B.C., for about three centuries, and then in the middle of the twenty-eighth century the Semitic rulers of Akkad contributed the first great Semitic leader in history, whom we now call Sargon of Akkad. Although these Akkadian Semites were obliged to make the revolutionary transition from the primitive nomadic life of the desert without writing, arts or institutions, to the civilized life of the Sumerian towns, in short to shift from the tent to the sun-dried brick house, they eventually outstripped their Sumerian teachers, on whom they were at first completely dependent.

Under Sargon they were so completely master of the Sumerian art of war that they gained the leadership of the Babylonian Plain, and the descendants of Sargon continued to rule there for some two hundred years. A noble stela recording the victories of Naramsin, an able ruler of this line, reveals to us the superiority of the Semitic Akkadian in art (Fig. 106). It is the first great Semitic work of art. A comparison with Fig. 99 will demonstrate how far the art of Babylonia had advanced since the early days of the Sumerian city-kingdoms. The Semite displayed his superiority in the same way in the magnificent cylinder seals of the time (Fig. 107). These, like the relief of Naramsin (Fig. 106), belong among the great works of art of all time.

While the Sumerian towns regained the leadership and

FIG. 108. DIORITE SHAFT BEARING THE GREAT CODE OF HAMMURAPI (early 21st century B.C.). (Compare Fig. 132.)

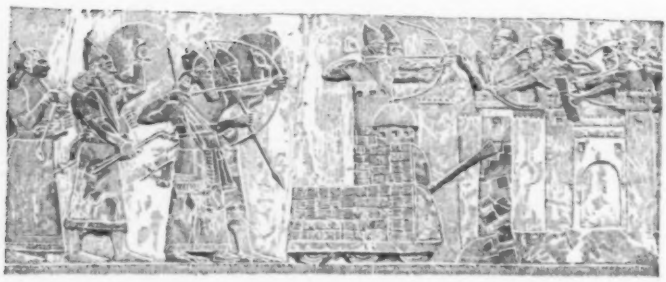


FIG. 109. A SIEGE ENGINE OF THE ASSYRIANS IN THE NINTH CENTURY B.C. A city at the right is being attacked by the Assyrian machine seen in the middle. The machine is on wheels operated by men concealed within. A turret with peep holes protects the commander of the machine, and a firing tower (also with peep holes) is occupied by two archers at the top. A heavy metal-tipped beam (which later passed to Europe as the "battering ram") is swung by concealed men against the walls and the results are seen in the falling fragments of the wall. It will be seen that this is a man-power tank lacking only gunpowder and gasoline power to make it a modern tank. Note the armor on front, over turret and around the firing tower. The scene is from a relief adorning the palace of King Assurnacirpal, and now in the British Museum.

struggled for centuries with waning power, to maintain it, the rise of a new Semitic line, living at the still insignificant town of Babylon, completely crushed the Sumerians and they never after regained the leadership of the region. Like Latin in the medieval church, their language still survived, especially in the literature of religion, and their cultural contributions had long since become a permanent element of western Asiatic civilization. The life of their towns, however, languished and declined, never to rise again. They are marked to-day by a line of mounds along the lower Euphrates, most of which still await excavation.

The powerful Semitic line which had elevated Bâbylon to the leadership of the plain to which the city gave its name, culminated in the rule of Hammurapi after 2100 B.C. A remarkable monument of this great man's administrative ability has survived to us in the splendid shaft bearing his code of laws in 3,600 lines, the earliest surviving code (Fig. 108). It is a remarkable expression of that ability to organize the material interests of life, especially business and commerce, which as we shall see, later contributed essentially to the rising civilization of Europe.

The reign of Hammurapi, which unified Babylonia and a considerable outlying region round about it, was the culmination of a thousand years of civilized development, from the thirty-first to the twenty-first century B.C. This is the first thousand years of which we can discern the general historical

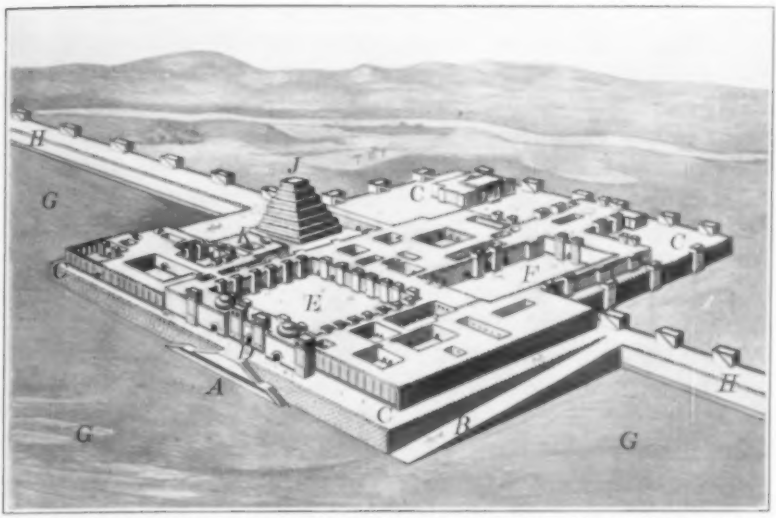



FIG. 110. RESTORATION OF THE GREAT PALACE OF SARGON II. AT KHORSABAD.—Eighth century B.C. (After Place.)

drift in western Asia. Hammurapi's successors were not able to maintain the unity of Babylonia, and the Semite yielded the leadership of the plain for many centuries to non-Semitic mountaineers, a new group of invaders of uncertain race whom we call Kassites. They were little better than barbarians and under them the life of the Babylonian plain relapsed into a stagnation so lethargic that it did not revive for almost a thousand years after Hammurapi's time.

Meantime another Semitic group which had found lodgment and a convenient stronghold on a spur of the eastern

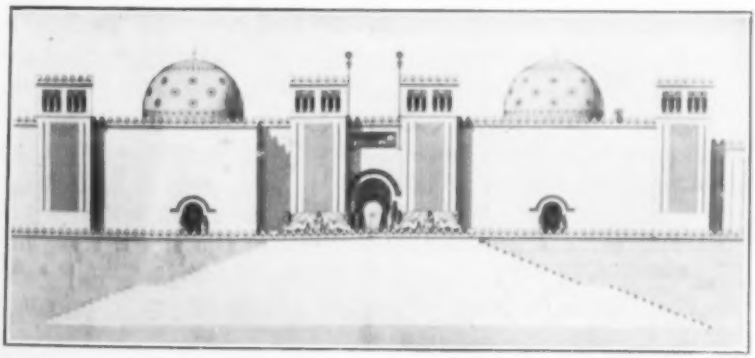


FIG. 111. ARCHED DOORWAYS OF THE FAÇADE OF SARGON II'S PALACE AT KHORSABAD. (Eighth century B.C.) This façade with its three arches was the ancestor of the Roman triumphal arch (Fig. 125), and eventually of the façade of the Christian cathedral with its three arched doorways.

mountains on the upper Tigris, had been developing in obscurity since the days of the early Sumerian city-kingdoms. Its stronghold was known as Assur, from which our familiar designation Assyria has descended. As a result of their exposed situation the Assyrians early produced hardy soldiers; and a nation of peasants and herdsmen, developing on a basis of old Sumerian civilization, with which were combined numerous characteristics of the mountainous north, became the greatest military power, not only of western Asia, but also of the whole ancient world of that age (Fig. 109).

By the middle of the eighth century B.C. the Assyrian kings were ruling a great Western Asiatic Empire, which was advancing its frontiers in almost all directions not limited by the desert. After the fall of the peoples along the eastern Mediterranean coast, including the Hebrews and Phœnicians, in the latter half of the eighth century B.C., the conquests of Sargon II. raised Assyria to a height of power and splendor never before enjoyed by an ancient people. Not far northeast of Nineveh Sargon erected a magnificent palace and city which he called Dur-Sharrukin ("Sargonburg," Fig. 110). It was fitting that this splendid architectural expression of Assyrian power should stand forth as the earliest great monumental architecture of Asia. The old Sumerian buildings, the Syrian palaces, and even the extensive capital city of the Hittites were insignificant compared with it. Its vast staircase, the first great monumental *escalier* in the history of architecture, the spacious arched doorways and enormous sentinel animals of sculptured stone, embellishing the imposing façade (Fig. 111), brilliant with designs in brightly colored glazed brick—all this proclaimed a new imperial age in western Asia. Under Sennacherib and Assurbanipal (Sardanapalus), the walls and splendid palaces of Nineveh stretched for two miles and a half along the banks of the Tigris. National greatness and power, which do so much to quicken the creative imagination of the architect, as we have observed in Egypt, had thus brought forth the first monumental architecture of Asia on a grand scale.

It is a significant fact that the iron mines of northeastern Asia Minor, which had been worked by the Hittites as far back as the thirteenth century B.C., made the Assyrian armies the first great armies of the ancient world to carry weapons of iron. Over against Assyrian ferocity in war, however, even though it was rendered the more dreadful by these terrible weapons, we should in fairness write down not a few other important considerations which essentially alter our estimate of

the character and effects of Assyrian supremacy in the ancient world. We can not even summarize these in this slight presentation, but one of them we have suggested in our references to Assyrian architecture, and another which ought not to be overlooked is the presence of a cuneiform library in the palace of Assurbanipal at Nineveh, the earliest known library in Asia, and centuries older than the oldest royal library among the Greeks.

While the Oriental world, or a large part of it, had been slowly coming under the domination of Assyria, the most fundamental changes had been going on in southeastern Europe as far back as the fifteenth century B.C. The pastures of inner Asia which stretch westward around the north end of the Caspian and along the northern shores of the Black Sea to the mouths of the Danube, have for ages been a great inter-continental sluice-way along which the nomadic peoples of Asia have swept into Europe. Somewhere along the Asiatic stretches of these grass lands in the third millennium B.C., there lived a group of nomads whom we call Indo-Europeans. Some of their descendants shifted southward along the east side of the Caspian to enter India, as the Sanscrit peoples; while a similar group pushed southwestward to reach the frontiers of Babylonia eventually as the Medes and Persians. Others drifting westward along the north side of the Black Sea finally found their way into the Balkan Peninsula. These were the ancestors of the Greeks. Such at least is the more probable reconstruction growing out of the scanty and difficult evidence now available.

Probably by 2000 B.C. these barbarian nomads, the ancestors of the Greeks, were driving their flocks southward through the passes of the Balkans. Reaching southern Greece by 1500 B.C., they had landed in Crete probably by 1400, and before 1000 B.C. the barbarian Greek tribes had taken possession of the remaining Greek islands and the coasts of Asia Minor, in short of the entire Ægean world. Thus the wonderful Cretan civilization which had grown up in southeastern Europe was overwhelmed and crushed by barbarous invaders who had hardly advanced beyond the Stone Age life of earlier Europe. Such of the unfortunate Cretans as were able to do so took to flight, escaping southward and eastward across the Mediterranean. The Pharaohs of the declining Egyptian Empire in the twelfth and thirteenth centuries B.C. were obliged to meet these northern Mediterranean fugitives as enemies, and the temple records of Egypt's wars at this time reveal to us the fleet of Ramses III.

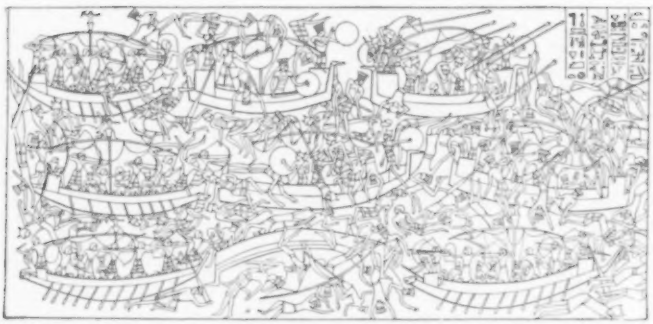


FIG. 112. ÆGEAN FUGITIVE FLEET DRIVEN FROM CRETE BY THE GREEK IMMIGRATION AND FIGHTING AN ENGAGEMENT WITH EGYPTIAN FLEET OF RAMSES III. OFF THE SYRIAN COAST. (Early 12th century B.C.) The scene is sculptured on the wall of a Theban temple of Ramses III. and is the earliest surviving representation of a naval battle. The five Cretan vessels may be distinguished from the Egyptian battleships by the fact that the Cretans have all lost their oars. One Cretan ship is overturned. The high bow and stern of these northern Mediterranean vessels shows that they have been copied from the early Egyptian craft, the first sea-going ships (Fig. 84). The Egyptian fleet kept its distance and won the battle by the use of archery, before which the heavy armed Cretans were helpless. (From a drawing in the author's "Ancient Times," by permission of Ginn & Co.)

crushing a fleet of the fleeing Cretans. It is the earliest naval battle of which we have any representation (Fig. 112). Some of the Cretans found a new home on the shores of Syria and Palestine and we are familiar with one group of them as the Philistines.

Civilization, after having maintained itself for perhaps a thousand years in extreme southeastern Europe, was thus overwhelmed and blotted out by the northern Greek barbarians, who were only prevented by the Mediterranean from extending their invasion southward and destroying the civilization of Egypt. We have here a striking illustration of how the Mediterranean saved Egypt from a destructive invasion such as those to which Babylonia and the Mesopotamian world were continually exposed. Under the shadow of the great civilizations of the Orient, the rude Greek nomads settled down among the wreckage of the Cretan and Mycenæan palaces. Cretan writing, the earliest writing in Europe, disappeared. The drawings on Greek pottery (Fig. 113) of the eighth century B.C. are not as good as those of the Paleolithic hunters in the caves of southern France ten thousand years earlier, and no better than many made by our own American Indians.

During the flourishing days of the Assyrian Empire, which stopped Greek colonization in Asia east of Tarsus, the life of Greece developed slowly under the influences of Oriental civilization. The civilization which thus arose in Europe *for the*

*second time* was exposed to the forces of civilized life in the Near East which had so long been converging with ever increasing power on the Greek world. The agencies by which these influences chiefly operated were commercial, and the routes along which they came were in the main through Asia Minor and across the Mediterranean. Through Asia Minor came Babylonian business usages, like credit, and weights and measures; while coinage, which arose in Asia Minor, reached the Greeks in the seventh century B.C.

The decline of Egypt and the destruction of the Cretan fleets left the Mediterranean free to exploitation by the maritime cities of the Phœnicians, which gained great commercial power and wealth, and became the common carriers of the Mediterranean after 1000 B.C. The Phœnicians were clever imitators and their leading cities became the centers of an active industrial life of which the output was a curious composite of Egyptian and Asiatic elements. The latter were in turn a composite of Sumerian, Akkadian, Assyrian and Hittite, but chiefly Sumero-

FIG. 113. ARCHAIC GREEK PAINTED POTTERY VASE OF THE DIPYLON TYPE DATING FROM THE EIGHTH CENTURY B.C. A comparison of the crude painted decoration on this vase with the wonderful Cretan decorated vases like Fig. 92, will illustrate the collapse of civilization due to the invasion of the cultivated Ægean world by the barbarian Greeks during the latter half of the second millennium B.C. (By courtesy of the Metropolitan Museum of Art, New York.)

FIG. 114. SILVER PLATTER MADE BY PHŒNICIAN CRAFTSMEN AND ENGRAVED BY THEM WITH EGYPTIAN DECORATIVE MOTIVES. Now in the Berlin Museum.

Semitic. Their arts and crafts and industrial processes, like the making of glass, the pouring of hollow casts, and the production of diaphanous linens, they learned from the Egyptians; while their decorative art combined the vegetable motives and the sentinel animals of the Nile with the balanced human and animal figures of the Euphrates (Figs. 114–115).

The Phœnicians learned shipbuilding from the Egyptians and copied the models of the Egyptian ships which had been entering their harbors since the thirtieth century B.C. (Fig. 84). This is quite evident from the paintings of early Phœnician ships preserved to us in the Egyptian tombs (Fig. 116), and dating from the fifteenth century B.C. Against the old tend-

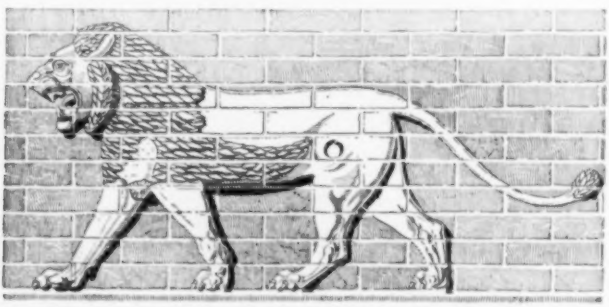


FIG. 115. IVORY COMB MADE BY PHŒNICIAN CRAFTSMEN AND DECORATED BY THEM WITH A LION DRAWN FROM ASSYRIAN SOURCES. The lion in gorgeously colored glazed brick was one of a line decorating the wall on both sides of a festival avenue of Nebuchadnezzar at Babylon. It was drawn by the Babylonian architects from such decorations in the Assyrian palaces (*e.g.*, Fig. 110).

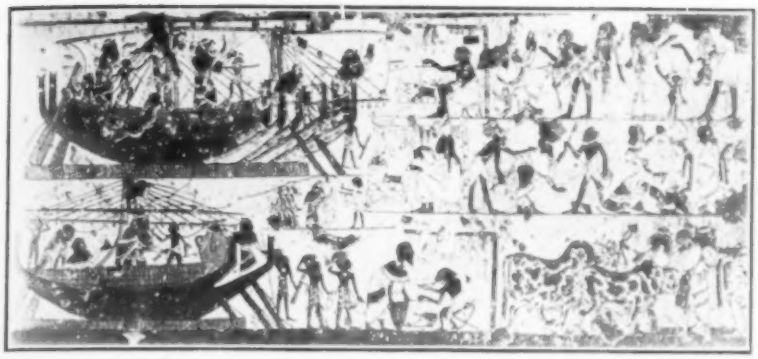


FIG. 116. PHŒNICIAN SHIPS LANDING AT AN EGYPTIAN MARKET PLACE IN THE 15TH CENTURY B.C. (After Daressy.) The model of the Phœnician craft, with high bow and stern, shows that the Phœnicians built them in imitation of the earliest Egyptian sea-going ships (Fig. 84). The Phœnician merchants, clearly marked by their foreign costume, may be seen trafficking in the Egyptian bazaars. It was here that they learned the arts and crafts and the decorative motives which they then so freely introduced in their home ports, and transmitted throughout the Mediterranean, and also as far east as Assyria and Babylonia. The scene is taken from a wall-painting in an Egyptian tomb at Thebes in Upper Egypt.

ency to attribute too great importance to the cultural activities of the Phœnicians in the eastern Mediterranean, there has been a natural reaction; but it has gone much too far, and has overlooked new and important evidence like the painting of the Phœnician ships in Fig. 116. Here the Phœnicians are shown trafficking in the Egyptian bazaars, whence they drew the processes of industrial art, as well as its decorative motives. Similarly, unfinished work in ivory has been found in Assyria, still bearing the Phœnician workman's scribbled notes. As practisers and distributors of borrowed Oriental arts throughout a large area in Western Asia, and very widely in the Mediterranean world, the Phœnicians played an imposing rôle in the early centuries of the last millennium before the Christian Era. Phœnician merchandise like the ivory comb of Fig. 115 was common as far west as the Spanish Peninsula, where such things are found in early burials.

DR. L. O. HOWARD,
President of the American Association for the Advancement of Science.

# THE PROGRESS OF SCIENCE

## THE ST. LOUIS MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE seventy-second meeting of the American Association for the Advancement of Science and the affiliated national scientific societies, held in St. Louis from December 29 to January 3, was attended by about 1,200 scientific men. In view of the fact that several important affiliated societies were meeting elsewhere, this attendance must be regarded as satisfactory and it is certain that the scientific sessions and the various addresses, lectures, conferences and other features of the program were of great interest and importance. Thus the large lecture room used by the physicists was crowded and the dinner of the botanists was attended by about 200.

The formal opening took place in the auditorium of the Soldan High School on Monday evening, December 29, Chancellor Hall, of Washington University, delivering the address of welcome. President Simon Flexner, director of the laboratories of the Rockefeller Institute for Medical Research, responded fittingly, after which he introduced the retiring president, Professor John M. Coulter, who delivered the address on "The Evolution of Botanical Research," which was printed in the issue of *Science* for January 2. At the conclusion of this address the revised constitution was read and unanimously adopted.

Among the measures adopted by the council were the following:

That the American Meteorological Society and the Southern Educational Society, be admitted as affiliated societies.

The council further declared itself as looking with favor on the affiliation of any national society which is interested primarily in scientific research.

That there be authorized the organization of members of the association in New Mexico, all or part of Texas and such other territory as may seem advisable into a Southwestern Division of the American Association for the Advancement of Science.

That arrangements for closer affiliation be authorized between the association and the academies of science of the Central States.

That the general adoption of the metric system by national and state governments be approved.

That the association will look with favor on any plan approved by the men of science in the country for the encouragement of research in engineering under the auspices of the government.

That the president be authorized to appoint a committee on international auxiliary languages to cooperate with a corresponding committee of the International Research Council.

That the American Association for the Advancement of Science will be pleased to cooperate with the National Physical Education Service in promoting physical education.

That sectional officers avoid placing on their programs papers relating to acute political questions on which public opinion is divided.

That approval be given to measures under consideration with the Carnegie Endowment for International Peace to enable the British, French and Italian equivalents of the American Association for the Advancement of Science to send delegates to the meeting to be held a year hence in Chicago.

That the sum of $4,500 be made available to the committee as grants for the ensuing year.

In accordance with the provision of the new constitution which calls for an executive committee of eight elected members to replace the old committee on policy the following were elected: J. McK. Cattell, H. L. Fairchild, Simon Flexner, W. J. Humphreys, D. T. MacDougal, A. A. Noyes, Herbert Osborn, H. B. Ward.


SOME MEMBERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE,
At the Entrance of the Soldan High School, Headquarters of the Association at St. Louis.

Dr. L. O. Howard, chief of the Bureau of Entomology and distinguished for his contributions to economic entomology, who has served the association as its permanent secretary for twenty-two years, was elected president of the association by unanimous vote. Dr. Howard had previously stated that in view of the great enlargement in the work of the Bureau of Entomology and the increasing responsibilities of the office of the permanent secretary of the association, he felt unable to continue to hold the two offices. The election of a permanent secretary was consequently referred to the executive committee with power and it is now announced that Dr. Burton E. Livingston, professor of plant physiology in the Johns Hopkins University, has been elected to the office. Dr. E. L. Nichols, who retired this year from the active work of the chair of physics at Cornell University, for some years chairman of the committee on policy of the association, was elected general secretary.

The meeting of the association next year will be held in Chicago and this will be one of larger convocation week meetings held at four-year intervals in Washington, New York and Chicago, in which all the affiliated societies are expected to cooperate. It will probably be the largest and most important meeting of scientific men hitherto held in this country or elsewhere.

## *THE DUES OF THE AMERICAN ASSOCIATION AND THE SALARIES OF SCIENTIFIC MEN*

THE revised constitution of the American Association for the Advancement of Science, as presented at the Baltimore meeting, was adopted at St. Louis with only one substantial change—an increase of the annual dues to five dollars. This change had been recommended, after careful consideration, by the committee on policy and the council and was adopted by unanimous vote at the opening general session of the association. The increase in the dues only meets the general situation. All the expenses of the association have increased in some such proportion, except the salaries of the officers, and it would be unfair to them and a bad example to other institutions, to retain nominal salaries paid in depreciated dollars. This has been done in the case of teachers in many institutions of learning and for scientific men in the service of the government, while commensurate with the increased cost of living have been the increases in wages for many of the working classes, and of the earnings of most professional and business men.

Institutions of learning and the scientific bureaus of the government have suffered alarming losses from their staffs. At the present time many men of science are hesitating between loyalty to their institutions and research work, on the one hand, and duty to the their families and the attraction of new opportunities, on the other. In one government bureau three men are now holding open offers of twenty to thirty thousand dollars a year to see whether the Congress will increase their salaries to six or eight thousand.

If men are driven away from positions where they are using their ability and their training for the general good, and if those who remain are compelled to use time that should be devoted to research or teaching to earning money from outside sources, the future of science and with it the welfare of the nation will be jeopardized. A generation might pass before there would be recovery from the resulting demoralization. It would be indeed humiliating to conquer Germany in war

SIR WILLIAM OSLER,

Regius Professor of Medicine at the University of Oxford and Honorary Professor of Medicine at the Johns Hopkins University, by whose death at the age of seventy years, the Anglo-American world loses its good and great physician.

and then permit it to surpass us in the arts of peace.

It is certainly unfortunate that the American Association should be compelled to increase its dues, as measured in dollars, at a time when all costs are advancing to such an extent that those living on fixed salaries find it extremely difficult to make both ends meet. It would, however, be a still more serious misfortune to permit the work of the association and its publications to be crippled. These are important factors in the advancement of science and in impressing on the general public the place of science in modern civilization and the need of maintaining research work for the national welfare.

The meetings of the association and the publications going to its members and read by a wide public are forces making for appreciation of the value of science to society and the need of giving adequate support to scientific research and to scientific men. Each member of the association contributes to this end and does his part to improve the situation for others as well as for himself. It is consequently to be hoped that no one will permit his membership to lapse on account of the necessary increase in nominal dues, but, on the contrary, that every member use all possible efforts to increase the membership of the association and to promote its influence and its usefulness.

## *GRANTS FOR RESEARCH OF THE AMERICAN ASSOCIATION*

At the St. Louis meeting of the association, the council assigned the sum of $4,500 to be expended by the Committee on Grants for Research during the year 1920. The members of the committee for the current year are: Henry Crew, chairman; W. B. Cannon, R. T. Chamberlin, G. N. Lewis, George T. Moore, G. H. Parker, Robert M. Yerkes, and Joel Stebbins, secretary.

The committee will hold a meeting in Washington in the month of April, when the distribution of the grants will be made. Applications for grants may be made under the general rules given below, which were adopted in 1917; but the committee especially invites suggestions from scientific men who may happen to know of cases where young or poorly supported investigators would be greatly helped by small grants.

1. Applications for grants may be made to the member of the committee representing the science in which the work falls or to the chairman or secretary of the committee. The committee will not depend upon applications, but will make inquiry as to the way in which research funds can be best expended to promote the advancement of science. In such inquiry the committee hopes to have the cooperation of scientific men and especially of the sectional committees of the association.

2. The committee will meet at the time of the annual meeting of the association or on the call of the chairman. Business may be transacted and grants may be made by correspondence. In such cases the rules of procedure formulated by the late Professor Pickering and printed in the issue of *Science* for May 23, 1913, will be followed.

3. Grants may be made to residents of any country, but preference will be given to residents of America.

4. Grants of sums of $500 or less are favored, but larger appropriations may be made. In some cases appropriations may be guaranteed for several years in advance.

5. Grants, as a rule, will be made for work which could not be done or would be very difficult to do without the grant. A grant will not ordinarily be made to defray living expenses.

6. The committee will not undertake to supervise in any way the work done by those who receive the grants. Unless otherwise provided, any apparatus or materials purchased will be the property of the individual receiving the grant.

7. No restriction is made as to publication, but the recipient of the grant should in the publication of his work acknowledge the aid given by the fund.

8. The recipient of the grant is expected to make to the secretary of the

committee a report in December of each year while the work is in progress and a final report when the work is accomplished. Each report should be accompanied by a financial statement of expenditures, with vouchers for the larger items when these can be supplied without difficulty.

9. The purposes for which grants are made and the grounds for making them will be published.

## SCIENTIFIC ITEMS

WE record with regret the death of Richard C. MacLaurin, president of the Massachusetts Institute of Technology, previously professor of mathematics in the University of New Zealand and of mathematical physics in Columbia University, and of George Macloskie, professor emeritus of biology in Princeton University.

OFFICIAL notice has been issued by the French Academy of Sciences of the award of the Bordin prize in mathematics to Dr. S. Lefschetz, assistant professor of mathematics in the University of Kansas, and of the Lalande prize in astronomy to Dr. V. M. Slipher, director of the Lowell Observatory at Flagstaff.—Dr. Jacques Loeb, of the Rockefeller Institute for Medical Research, Dr. Robert Andrews Millikan, of the University of Chicago, Dr. Arthur Gordon Webster, of Clark University, and Dr. W. W. Campbell, of Lick Observatory, have been elected honorary members of the Royal Institution of Great Britain and Ireland.

AT the dinner of the alumni of the Massachusetts Institute of Technology, held in Cambridge on January 10, it was announced that the endowment fund of four million dollars had been obtained by the alumni, thus securing the gift of an equal sum from the hitherto anonymous "Mr. Smith." It was revealed that "Mr. Smith," who has now given eleven million dollars to the Massachusetts Institute of Technology, is Mr. George Eastman, president of the Eastman Kodak Company.